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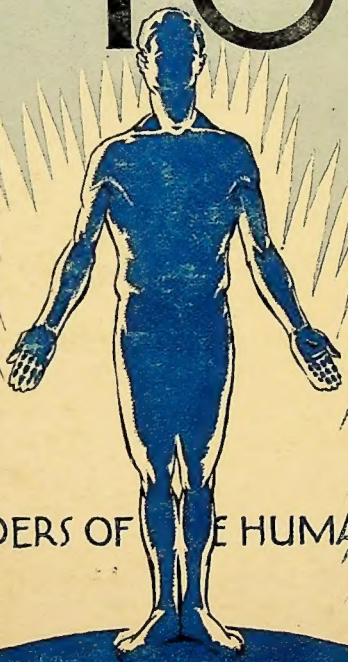

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To
My Little Girl
Patricia Margaret
the
Observation of Whose Development
in
Body and Mind
Has Lent an Added Appreciation
of
the Existence of Both
Design
and
Designer

WONDERS OF THE HUMAN BODY

THIS book attempts to present, simply and understandably, a discussion of certain structures and mechanisms of the human body. It makes no claim to be, in any sense, a complete treatise on the subjects considered, but, rather, seeks to indicate many evidences of design which point irresistibly to a Supreme Designer.

In the assembling of facts, many authors have been consulted. The writer acknowledges his indebtedness to "Why We Behave Like Human Beings" by Dorsey; to a series of articles in "Signs of the Times" by Dr. H. O. Swartout; to Dr. Grenfell's book on the body; to "Natural Theology" by Paley, and other sources.

His own intensive study of the human body and his work as a surgeon, extending over many years, have brought to the author a measure of familiarity with his theme.

His viewpoint will be better understood if a few fundamental articles of faith are mentioned. It is believed that:

1. There is a personal God who is the Creator, Designer, and Architect of the entire universe, animate and inanimate. This Personality possesses, in an infinite degree, those attributes

which, in a finite degree, He has conferred on His human creatures.

In other words, God lives, thinks, plans, loves, hates, rewards, punishes, and exercises omnipotent power according to the pleasure of His perfect and Divine will.

2. In the body are seen innumerable evidences of Divine forethought. This is the great Truth which, it is hoped, will be presented in such convincing fashion as will bring to the reader a vital consciousness of God.

3. The theory of evolution is rejected as being contrary to the clear facts of Science as well as to the plain statements of Scripture.

4. Jesus Christ was God, incarnate in human form, with a human body voluntarily assumed in order to carry out His plan for the redemption of the race, ruined by sin and condemned thereby to eternal banishment from God; that He died on the Cross, shedding His blood in substitutionary, atoning sacrifice, and so accomplished salvation; that He rose from the dead and ascended to heaven from whence His return is imminently expected.

5. The world has as its god, Satan, the Prince of the power of the air, and is in the grip of an intellectual Bolshevism which is predomi-

nantly materialistic, defiant towards God and hostile to strong evidence which proves His existence.

6. The Bible is infallible and inerrant from Gen. 1:1 to Rev. 22:21, and is, in its entirety, the Word of God.

The hope is expressed that this unpretentious book will meet a vital and widespread need in today's world which exhibits a gross rejection of those eternal verities upon which depend the future of the individual and the destiny of the race.

In the Bible, there are many interesting references to the body. In the 139th Psalm, verses 13-16, we read:

> "Thou hast covered me in my mother's womb. I will praise thee; for I am fearfully and wonderfully made: . . . my substance was not hid from thee, when I was made in secret, and curiously (skilfully) wrought in the lowest parts of the EARTH. Thine eyes did see my substance, yet being unperfect (incomplete); and in thy book all my members were written, which in continuance were fashioned, when as yet there was none of them."

This reveals the oversight of God from the earliest germ-cell throughout its entire embryological development before birth. Also, that the body was formed from "earth" or "dust," an

idea which, at one time, was ridiculed by a skeptical and unbelieving science, but now that the analysis of protoplasm is fairly well known, is seen to be absolutely correct. When the life principle leaves the body, it goes back to dust.

The supreme importance of the body is shown by the fact that God, the Architect, drew a plan which contained the various parts of the body—bones, muscles, nerves, bloodvessels, tissues and organs. This book which contains the plan is another of those wonderful volumes to be found in God's library. We shall be studying these books throughout eternity.

The great care exercised in the creation of the body can be understood when we remember I Cor. 3:16-17:

> "Know ye not that ye are the temple of God, and that the Spirit of God dwelleth in you? . . . The temple of God is holy, which temple ye are."

The truth enunciated here is beyond our comprehension. But, in some mysterious way, it tells us that the third Person of the Trinity has taken up His residence within us. How this is accomplished, it is not possible to understand, but the sublimity of the idea ought to lead to a care of the body, seeing that we have such a Guest.

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Chapter One

THE FIRST CELL AND ITS PROGENY

IT is common knowledge that all living organisms originate in one tiny cell of protoplasm, about one one hundred and twenty-fifth of an inch in diameter. Protoplasm, which is the basis of all life, is probably the most mysterious and complex combination of chemical elements known to man.

In it resides the elusive life-principle which has never yet been discovered or isolated. Within this microscopic speck, which seems to be nothing more than a little blob of jelly, semi-fluid, transparent, and colorless, are wrapped up amazing possibilities.

This single cell has a thin containing wall or covering, holding together the very precious granules in which resides the power of bringing to pass the changes which are necessary before the completed body can result. The small granular particles are stainable and are called CHROMATIN.

They appear as a central mass, to which the name, NUCLEUS, is given. Outside this central spot the protoplasm is known as the CYTOPLASM.

What is protoplasm? The answer involves us in the most mysterious investigation which can occupy the human mind. As far as now known, all things in the universe are made up of 92 chemical elements, in various combinations. Of these 92, God set aside 16 or more, from which He decided to create the bodies of His creatures who were to inhabit the earth.

Protoplasm is 72% Oxygen, 13.5% Carbon, 9.1% Hydrogen, and 2.5% Nitrogen. This leaves about 3% made up of small amounts of phosphorus, chlorine, sulphur, sodium, potassium, calcium, magnesium, iron and silicon, with a touch of fluorine, iodine and manganese. To this is added about 70% water. Some authorities add 5 or 6 others in very minute quantities.

Dr. E. F. Lawson of London, facetiously, gives the following analysis of a person weighing 140 pounds: Enough water to fill a ten-gallon keg, enough fat for seven bars of soap, enough carbon for 9000 lead pencils, enough phosphorus to make 2200 match heads, sufficient magnesium for one dose of salts, enough iron to make a medium-sized nail, sufficient lime to whitewash a chicken coop, and enough sulphur to rid a terrier dog of fleas.

Protoplasm eats. If it does not get food, it

dies. As it burns its food-fuel, ashes are formed and must be removed—or death results. It can move, either by pushing itself forward in a strange method of projection, or sometimes, the cells are equipped with tiny oars—called cilia—which whip it along.

Protoplasm dislikes being touched, and exhibits real irritation when anything comes into contact with it, by immediately removing itself from the unwelcome visitor. Majestic isolation! It grows and lives and can reproduce itself from one generation to another.

How long may protoplasm live? Woodruff kept the one-celled paramoecium growing to more than 10,000 generations and they were still going strong. If each paramoecium's life were the same length as that of man, that would be equal to 250,000 years! Would Adam and Eve and their descendants have lived forever if sin had not taken possession? It is something to think about.

The materialists will have nothing to do with God. Well, who but God could plan and create these amazing protoplasmic units with their remarkable powers?

The condensed portion of the primary cell, known as the nucleus, is the vital and essential

part. The Chromatin (colored stuff) substance of which it is composed, exhibits the most amazing and complex qualities and powers. Briefly and simply, this is what takes place.

The male and female cells, known respectively as the sperm and the ovum, contain, of course, these bits of chromatin. The essential contents of these nuclear elements are called chromosomes which may be described as strings of beads, the latter bearing the name of genes or chromomeres. These infinitesimal genes carry in their tiny bodies all the characteristics of the human body. For instance, one bead has the hair color, another the shape of the nose, others the shape of the mouth, contour of the face, and so on. In all human cells there are forty-eight chromosomes. In animals, they vary in number and shape.

The number in monkeys is 54; dogs 22; cats 36; horses 38; drosophila (the fruit-fly) 4. Some insects have more than 100 while certain radiolaria possess more than 1600. From the standpoint of evolution, there is neither rhyme nor reason to the number of chromosomes. Believers in an animal ancestry for mankind derive no comfort from this phenomenon.

You are what you are, then, because of your

chromosomes. Your parents, your grandparents, and your ancestors as far back as you care to go, have handed down to you all the qualities and peculiarities which distinguish you from all other individuals on earth. There are countless millions of possibilities from the arrangement of the genes and their permutations.

The sperm and ovum meet and unite. Before actual union takes place, they undergo a wonderful change which consists in the reduction by one-half of the number of their chromosomes. Instead of 48 each, they diminish to 24 each, so that when union is complete, the original number of 48 is restored.

Let your imagination have full rein now as you attempt to picture what is happening inside of this miraculous little blob of protoplasmic jelly. Wonder of wonders! The central portion, or nucleus with its 48 chromosomes, now undergoes a process of multiplication and instead of 48 there are 96. Half of these rush to one end of the jelly-ball and half to the other end, awaiting the next step which occurs immediately. **The cell pinches itself in two in the middle!** This is done in such a way that each new cell finds itself possessed of exactly 48 chromosomes.

The two daughter cells repeat the operation and there are now four granddaughters, the process continuing until there are millions upon millions and the embryonic form is complete.

It is not difficult to see—although we may not understand it—how heredity works by utilizing all these characteristics which are embodied in the beads on the string. There are endless and almost infinite different combinations possible in the making of new human lives. Could anything be more wonderful than this?

Such a miracle is possible only to Omniscience and Omnipotence. Every single cell is stamped with the word "God"!

Suppose it became possible for man to devise some way by which a bit of protoplasm might be manufactured from lifeless materials, is it within the range of possibility that man could place along these chromosomes these "countless" chromomeres, the bearers of all hereditary characters? This is absolutely inconceivable. Only an Omniscient and Omnipotent Creator could do that. And yet, every human who has ever entered this world carries these phenomenal bits of protoplasmic miracle.

The progeny of that first tiny cell, number, in every human body, at least twenty-six thousand

billion. What an astonishing family! We may think, then, of our bodies as huge cities, the inhabitants of which are these billions of little "people," all specialists of one kind or another.

There are carpenters, masons, plasterers and plumbers; electricians, ordinary laborers, scavengers, gardeners, and cooks; servants, policemen, soldiers, sailors, lawyers, merchants and doctors. Here is a busy, peaceful, harmonious city, the citizens of which carry on ceaselessly, night and day, immense and complex industries. They work independently and yet very dependently. If one group, for any reason, were to stop work, all other groups would die. Every part must be kept in health in order that the welfare of the whole may be preserved. There is no jealousy, no schism. The cells are very clannish. If an enemy attacks one part, all parts rush to the rescue or send reinforcements of one kind or another.

This seems to be the idea behind the interesting statement of I Corinthians 12:14-21, 26:

> "For the body is not one member, but many. If the foot shall say, Because I am not the hand, I am not of the body; is it therefore not of the body? And if the ear shall say, Because I am not the eye, I am not of the body; is it therefore not of the body? If the whole body were an eye, where were the hearing?

> If the whole were hearing, where were the smelling? But now HATH GOD SET the members every one of them in the body, as it hath pleased him. And if they were all one member, where were the body? But now are they many members, yet but one body. And the eye cannot say unto the hand, I have no need of thee: nor again the head to the feet, I have no need of you . . . And whether one member suffers all the members suffer with it."

Skin Cells

The frontier or outpost army. These cells are set close together in the form of a soft, silky, sensitive tissue, protecting and holding in the rest of the body. The superficial layers of skin cells are constantly being shed and replaced by new ones. If any part of the body is bandaged and the bandage kept in place for a few days and then removed, you will see a copious supply of "dandruffy" material,—dead cells.

1. The skin is a protective leather jacket. It is tough and flexible and its surface will bear considerable rubbing or scratching without pain or damage. If undue pressure is applied to any portion, this area attempts to protect itself by becoming thick. And so,—corns and callouses. The surface cells, pressed on, seem to have said: "Something is trying to get in—pressing hard—let's build a wall and keep it out!"

2. It is a first-class repeller and killer of germs. This too, in spite of being very porous. Your body is covered at all times with countless bacteria waiting for a suitable opening, but they cannot enter until the skin is broken.

3. It serves as an admirable sign-board, giving much information to the observant diagnostician. Redness indicates fever:—lack of color, certain blood diseases. Chronic diseases show peculiar skin changes depending on the character of the infection.

4. It is a combined umbrella and sunshade. The cells in the skin have a large amount of keratin, a chemical like gelatin or white of egg, with peculiar and very necessary properties. It resists almost all natural solvents, such as water, oils, dilute acids, alkalies and other chemical liquids.

As a sunshade, it protects the delicate cells of the internal organs against the deadly ultra-violet rays of the sun; these rays cause the development in the skin of the chemical, melanin, the cause of summer tan. This device blocks out the rays if the exposure is not too sudden and intense.

Another amazing proof of God's forethought

is seen in the existence, thirty-five or forty miles above the earth, of a blanket of ozone gas, one-eighth of an inch thick, which effectively prevents the entrance into the earth's atmosphere of a dangerous amount of rays from the sun, which otherwise would menace the life of every individual exposed to them. Could evolution possibly accomplish this amazing device?

5. The skin is a combined thermometer and thermostat. It registers and exercises a certain control over temperature.

6. The skin provides a very efficient set of heat insulators for the body, like asbestos around steam pipes, or the thick heat-resistant walls of the refrigerator, to keep out heat and keep in the cold.

7. It is a cupboard or stock-room of the body for all kinds of things, — water, potent gland chemicals, salt and other materials.

8. It is the principal organ of touch. There are at least five different sensations, light pressure, heavy pressure, heat, cold, and pain. Nerve endings for each of these sensations occupy definite locations in the skin.

Dr. Swartout writes:

> "You see, the covering of your body is much more than a mere covering. The wall of the house you live in is not a dead shell, inside of

which your life processes go on. It is a living, active organ — not simply a box for a human machine, but a vital part of the machine itself. When you think of the number and variety of its uses, with its clever adaptation to all of them, your body's covering becomes as effective a witness to the wisdom of its Maker as any of its other members."

The Chemists

These specialists manufacture with apparent ease and precision, the most complex chemicals. The gland chemists in the stomach, for instance. When the message leaves the mouth:—"Food going down at once—gastric juice needed immediately!" — there is instant response to the request.

The little workers rush to their source of supply, the blood. They must have hydrogen and chlorine. The former is in the water which makes up 90% of the blood, and the salt in the blood, which is chloride of sodium, contains the chlorine. These two, hydrogen and chlorine, are brought together and the result is hydrochloric acid. This is comparatively simple. Three complex substances known as enzymes are also manufactured inside the stomach — pepsin, which splits proteins; rennin, which coagulates milk and converts casein to paracasein; lipase, which splits fats in emulsion, such as cream.

Can you explain how this company of chemists so easily provide these necessities — manufacturing a free acid from an alkaline or neutral fluid? And they accomplish this mysterious result without the slightest difficulty whenever required to do so.

The chemists of the ductless glands manufacture the deadliest poisons known and their work will be described in a later section.

Day Laborers

These are the muscle cells that carry us from place to place, and often grow weary with their load, especially when the burden is heavy, or they are not in good condition.

Scavengers

The cells of kidneys, skin, and lungs, excrete poisonous products, the ashes and garbage brought to them by the bloodstream, the train which carries the refuse dumped into it by the busy workers who may have said: "Take it away, or we shall choke!"

The Policemen

These are the white blood-cells, the leucocytes, nattily attired in their white coats. They are the most expert and indefatigable fighters in the world. When a burglar gets inside the body, an

officer is always there to meet him and ready to fight to a finish. How different from the policemen in our cities! Who ever heard of a policeman being around when a burglary is committed?

The Experts in Charge of the Broadcasting and Receiving System

In the central nervous system resides "General Headquarters," or "H. Q." as we shall call him. Here in the brain and spinal cord, messages are being received from all parts of the body along a system of telegraph wires or nerves, the sensory nerves; orders are being sent out over another telegraphic system — the motor nerves. These will be described later.

Vital Functions

Typical of these are breathing and heart-beating. God has placed these outside your control —a very wise provision. Without paying any attention to it, you are breathing about 18 times per minute. You do not have to keep your mind on this necessary operation — it works itself. When you lie down at night to sleep, you do not ask your friends to sit beside you in case you should suddenly stop the action of the strong muscular bellows which must work constantly to keep you alive. You do not need someone to

give you a frequent dig in the ribs to remind you to breathe. Day and night this function is performed with the greatest ease—unless you have an attack of asthma!

As soon as the carbon dioxide in the blood has reached a certain amount, the respiratory center in the brain is stimulated, and orders are immediately communicated to the many muscles engaged in pulling in air, to get busy. This occurs every few seconds and shows how the Creator worked out the problem of continuous breathing.

If you want to experiment with your will power, it may be possible for you to hold your breath until you fall unconscious, when you will begin to breathe again. A poor method of attempting suicide!

Your heart beats approximately 72 times a minute—40,000,000 times a year. Of course, it varies occasionally. If you have fallen in love and are sitting beside her for the first time—it may seem as if the old heart were pounding about 170 beats a minute, but this is a temporary aberration and will presently correct itself!

A Marvel of Perfection

The body is a mechanical masterpiece. A machine is defined as: "Any contrivance used in doing work from the simplest hand-tool to the

most complicated printing-press or locomotive." Judged by this definition, there are millions of machines in our bodies, exemplifying all the mechanical principles found in our modern factories. We have the lever, the wheel and axle, the pulley, and the inclined plane, the wedge and the screw. Besides these, think of the psychological principles at work, about which nothing is understood.

But, the body is more than a mechanism—it is a living organism. Each cellular inhabitant is born, eats, moves (many of them), excretes, lives, performs its intricate work, and eventually dies.

Some cells live for many years without change, as those in bone, cartilage (gristle), muscle, tendon, and nerve. But, the majority are short-lived. Our wonder increases when we discover that the body is self-stoking, self-regulating, self-repairing, and self-reproducing. As new cells are born they are sent to their destined lifework. There is no grumbling; no complaints; no strikes; no learning their job. They know exactly what to do.

The houses we inhabit are pulled down, stone by stone, brick by brick, and rebuilt as rapidly as destroyed. All the furniture and fixtures are

severally removed and replaced, particle by particle. No eye can follow the process, nor detect any change in the architecture of the pile. No organic function is interfered with for a second.

The whole structure of the lungs is removed and replaced without the suspension of a single breath. The heart loses not a beat. The eye is taken to pieces, the windows of vision reglazed, without any irritation or interference with their function. New stomachs are supplied without the loss of a single meal.

This wonderful body, however, is not you. It is yours. You are spending a few years in it. And while you make it your abode, it works for you.

Chapter Two

INSIDE YOUR SKULL

THE skull, or box of bone which contains and protects the all-important brain, varies in shape and thickness. The delicate brain substance is easily injured, and so, Divine wisdom placed it in a position of utmost safety.

With 70% water, there is always "water on the brain," but under ordinary circumstances no harm is done! If the percentage of water were increased, the brain, literally, would be "soft"; if decreased, too hard. Apparently this latter condition was that of a man injured in a certain shooting affray. The reporter who wrote the account, said: "The bullet penetrated the skull and entered the wood-work."

The dome-shaped, bony skull is a very strong and rigid affair. It spreads the force of blows so as to minimize the shock. The bones are so constructed and put together as to provide the fullest measure of protection. The box has a hard layer of bone on the outside, another hard layer inside, and a spongy layer between. Because of this peculiar structure, it is possible to break through the outer layer, without any injury to the inner layer or to the brain.

Your brain sits majestically on its throne as King of the body, governing your moral sense, emotions, intellect, judgment, will, memory, disposition, special senses and voluntary actions.

It has four parts; cerebrum, the largest portion; cerebellum, or little brain; the medulla, a direct continuation of the spinal cord; and the pons, or bridge, which connects these three parts.

Cerebrum

If you would like to know what this is like as it fits snugly beneath the roof of your skull, imagine half a pecan kernel, grown so large that it weighs more than two pounds, and so stout that it is more than half as thick as it is broad. This will give you a fair idea of its shape, size, and general appearance.

It is marked, grooved, and scored by a thousand fine lines and furrows, with many irregular ridges and ditches over its entire surface. It is covered with 10 or 12,000,000,000, nerve cells or neurons which are constantly receiving messages, more or less urgent, from all parts of the body, and transmitting them to "H. Q."

Definite areas are connected with definite parts of the body. The upper part of the cerebrum seems to control the lower part of the body, and vice versa. While nearly all of the activities of

the body have to do with both sides of the brain, speech is controlled by one side only. If you are right-handed, this is the left side. Pressure on, or injury to this small area, destroys the power of speech.

When a "stroke" of apoplexy occurs, which is caused by the rupture of a blood vessel in the brain, blood is poured out and, if on the left side, presses on the speech center. The power to speak is lost. If the patient lives long enough, it occasionally happens that a new speech area is formed on the other side. What amazing work has been accomplished inside in order to make this possible? Did the mysterious little workers issue an emergency call to discuss the situation? Were orders given to get busy on the right side and see what might be done? Who knows?

The following motor areas have been localized: face, body, opening of jaws, closing of jaws, mouth, tongue, neck, vocal cords, nose, eyelid, ear, chest, shoulder, arm, elbow, wrist, fingers, trunk, hip, leg, knee, ankle, foot, toes.

This means that if your right thumb is paralyzed, you have an injury to the left side of the cerebrum in this small area.

The sensory areas for sight, hearing, and smell

have been located on the cerebrum, but the taste centers are not well known.

On the outside of the brain is the gray matter; on the inside, white. The billions of gray cells are much more numerous in man than in animals. In animals, also, the lines and furrows are much smaller and fewer. In a gorilla, the surface or gray matter amounts to about 540 centimeters; in man, it often reaches 2000. From the rodents down, the surface is practically flat and unmarked.

It is clear that size of brain alone does not give superior intellect. The marks, lines, furrows, have much to do with this. Large brains may or may not be associated with great mentality. Turgueneff, the Russian novelist, had a brain which weighed 2012 grams. Two others have been known to exceed this in size, and one of them belonged to an imbecile!

It seems incredible that life and the performance of the different body functions are possible, even when the brain is partially or wholly destroyed. And yet, this would seem to be the case.

Alwin Dressler, in the Illustrated Observer, Berlin, Sept. 9, 1933, gives some amazing facts:

"More and more, scientific evidence is accumulating to prove that individuals with badly injured or destroyed brains, continue to think, and speak, and act normally. This proves conclusively that the brain is not the seat of the soul, but a secondary organ, fed and directed by a superior, immortal force.... The noted scientist, Prof. G. W. Surya, describes the case of a man who had been insane for years, but suddenly became normal shortly before his death, and asked to see his family. His request was granted, and everyone was amazed to hear him speak quite reasonably. The autopsy revealed that there was practically nothing of the brain left in the brain-pan. Some disease process had gradually destroyed its substance. The mystery of his brief return to normalcy remained unsolved....

The famous German physician, Hufeland, who died in 1836, described a man in full command of his mental faculties, but paralyzed, whose skull was found to contain nothing but a little water. There was not a trace of brain substance anywhere, yet the man had remained normal to the last.

Prof. Schmick quotes the case of a man who quite unexpectedly fell to the ground and died in full consciousness. Most of his brain was decomposed into a pus-like liquid. Obviously, it had been in this condition for some time without interfering with the subject's mental processes....

The German brain specialist, Schleich, has treated at least 20 cases of injuries to the brain, with partial destruction of its mass,

without noticing any symptoms of mental derangement."

These startling facts may well cause us to ponder. What emergency power has the Creator conferred upon the brain, whereby it is able to perform its functions when scarcely any of its original substance is left? To this miraculous puzzle, science has no answer.

Dorsey writes on the work of the cerebrum in this way:

> "It is because of cerebral gray matter's range of behaviour permutations, that a Greek professor could devote a lifetime to the solution of a new diacritical mark on an ancient manuscript—to discover just before he died, that it was a fly-speck!
>
> A child born without a cerebrum, lived four years. It preserved the reflexes it was born with: sucking, crying, sneezing, grasping, etc. It never learned to recognize its mother, nor to hold a bottle. It never learned any controlled or voluntary motions. . . . Of nervous or mental growth there was none; of intelligence, less than that of a decerebrate frog. If the cerebrum must be labelled, call it the ORGAN OF ASSOCIATIVE MEMORY AND THE STRUCTURAL FOUNDATION OF HUMAN CULTURE.
>
> The cortex (outside) of the cerebrum is a clearing house — a deliberative assembly to which reports of matters requiring consideration, come in from the various groups or bureaus, and, in which, they are considered and

action taken through proper channels. But, before they enter this highest court, they must pass through one or more of the lower correlation centers."

Cerebellum

This portion of the brain is somewhat like a long, slender finger, crooked up into an almost complete ring, with a rounded mass extending out from each face of the ring. This little brain is covered, like the cerebrum, with ridges and ditches.

Its chief function is to keep us right side up. To preserve our balance and adjust our equilibrium is an enormously involved process. Probably 1,000,000,000 nerve cells take part in every move we make to keep our bodies straight.

To the cerebellum come messages from the little scouts in the soles of our feet, from the receptors in all joints, tendons, ligaments, and muscles, from the sight receptors in our eyes, and also from the position and motion controls in our inner ears.

Some neurologists claim that the cerebellum co-ordinates movements of tongue, lips, and vocal cords, and therefore, in some way, regulates speech. The messages it receives are correlated and co-ordinated by the cerebrum. That is, your cerebrum issues orders which set your muscles

to work, and the cerebellum brings about their harmonious action.

If "H. Q." says: "Pick up a glass of water and take a drink!" your arm and hand move surely and easily to carry out the order. If your cerebellum were not working properly, the arm would move in a series of irregular jerks. You would have difficulty in locating the glass; if you did reach it and pick it up, you would probably spill most or all of the water before it reached your mouth.

Every step we take calls into action 300 muscles; to balance the head, 20 muscles are needed; to balance the spine, 144.

The cerebellum is the great co-ordinator and harmonizer of muscular action.

Medulla

This is an enlargement of the spinal cord, just inside the skull. It is probably the busiest center of Central. Here end eight of the twelve, very important head nerves. Through this pass most of the messages from one division of Central to another.

Every mark you make with a pencil has first travelled across the medulla. It controls such important actions as winking, sneezing, coughing, chewing, sucking, swallowing, and vomiting, as

well as the secretion of saliva in the mouth, and gastric juice in the stomach. It is also the center for breathing, for regulating the size of the blood vessels, and for speeding up and slowing down the action of the heart.

How does the medulla, which is hollow and weighs only one-twentieth of the entire brain, control so many vital functions? In some unimaginable manner, it receives impulses and proceeds to set this or that mechanism to work.

Did you ever step suddenly into a tub of cold water and watch what has happened to your skin? The tiny and ever watchful receptors in the feet have lost no time in telegraphing the news. They have demanded from Central warmth and protection for the vital internal organs. "The boss has stepped into something frightfully cold —we don't know how far he's going—send all available blood inside!"

The vital and precious internal parts must be kept warm and living at all costs. Body temperature is of great importance and an enemy seems to be attacking. "General H. Q." is on the job and down goes a sharp order to the thousands of miles of tiny surface blood vessels to squeeze their blood into these vital places. Result—skin gets pale.

You are in a tub of hot water, temperature 105; forehead dotted with beads of perspiration. You put your hand in a basin of ice water. The sweat glands immediately stop working. The scouts on the skin have telegraphed their news: "The boss seems to be getting into ice water—never know what that man's going to do—be careful!"—And the beads of perspiration cease to form.

Life is possible even after a bullet has penetrated the higher centers; but a small bird-shot, fired into the medulla, kills. If the cerebellum is injured, but not fatally, the cerebrum will take over some of its functions. The cerebrum seems to have incalculable capacity. It can learn to do anything.

The Ganglia

These are masses of nerve cells, near the spinal cord. These cells relay the impulses to others in the cord itself. These latter have power to send out orders to the muscles.

Dr. Swartout writes on this:

> "What happens when you touch a hot iron? You jerk your finger away before you have time to think what you are doing. The injured nerve endings in your finger send impulses over their nerve fibres to the ganglia. These cells relay the impulses to others in the cord

itself. These have power to send out orders to the muscles to contract and pull away your finger.

The impulses reach not only the cord, but go on up to the brain, and you feel that you have been burned. The larger the burned area, the stronger and more numerous the impulses, the more extensive the orders to the muscles, and the greater the sensation of pain.

If you have been burned before and know what to do, as soon as your brain becomes conscious of the injury, it exercises its power of judgment, and then sends out a series of orders to all the muscles that must act to take you to a doctor, or to enable you to dress the burn yourself.

The chain of events that makes you jerk your finger away from a hot iron, we call REFLEX ACTION. That which takes you to a doctor is VOLUNTARY action. Many of the actions of your muscles are reflex. Few of them are painful. Some take place without your knowing it. When you cough you usually do so because of a tickling in your throat. The cough is reflex."

Think for a moment what happens when you cough. A collection of mucus or, it may be, something else, is in the passage from the lungs. The sensitive cells on the surface of the passage feel the presence of this foreign material. They are irritated. "Hello, Central! There's something in our throat. Tell the muscles to fire it out!" The answer to this is the cough which tends to expel forcibly the troublesome cause of the discomfort.

The Spinal Cord

This is eighteen inches long and extends from the medulla down through the spinal column, in the passage so marvelously constructed for it, from openings in each bone comprising the backbone. It receives thirty-one pairs of spinal nerves, which supply skin, motor mechanism, and parts of the internal organs.

There are many ingenious devices used to protect the brain, the most important organ in the body, but it is possible to mention only a few of them.

The brain is covered with an exceedingly tough membrane, called the DURA MATER. It is this which saves the brain from injury in a large number of cases of fracture of the skull. It gives off certain partitions which serve to separate and steady various parts of the brain. This membrane lines the inside of the skull and is attached closely to it, especially at certain points, so that it constitutes a sort of bag inside of which is the brain, and the whole is slung from the bony roof of the box. The DURA MATER provides numerous channels for the drainage of the brain tissue.

There are two other coverings underneath the dura, very thin and delicate, called the ARACHNOID AND PIA MATER. The latter dips down

into the cerebral fissures, and between these two is an important space, holding cerebro-spinal fluid. The brain rests upon this as on a water-bed. This water-bed is chiefly located just where it is most required, viz., under the base of the brain, and especially behind, where the more vital parts are.

In this way injurious effects of sudden jolts are obviated, and the chance of injury much lessened.

Two membranous partitions grow inward from the dura mater. One extends vertically downward between the two halves of the cerebrum, and the other, horizontally, between the cerebellum and the back part of the cerebrum. They suspend the brain in its box and keep it from rolling about. Otherwise, sudden jars would result in severe shock and concussion.

In the floor of the skull and at the back part of the eye are little openings to admit blood-vessels and nerves. These are very important and most of them are deeply covered by other structures. Your skull and its brain constitute a veritable multiple-walled fort, the gates to which are strongly fortified. This is the real "Holy of Holies" where dwells the Monarch who rules supreme as long as life lasts.

Chapter Three

INSIDE YOUR MOUTH

OPEN your mouth and examine your 32 teeth—that many, if you have all you are supposed to possess! You are looking at the finished product of expert bone builders, whose sole job is to build two sets of teeth.

Teeth are made up of complex chemical substances. On the outside is enamel, the hardest material in the body; also there are dentine, and cement. A hole in the root of each tooth carries nerves and blood vessels, to give it life and sensation; each tooth fits into a socket exactly suited to its size and shape.

Baby eventually has 20 teeth, but is not born with them. The tiny carpenters know that baby's food at first will be liquid and will not require to be chewed. So, we can imagine these workers taking life easy for a while. Then, one day, the chief carpenter summons his helpers. "Boys, our holidays are about over — the little fellow will soon be wanting something to chew. We begin operations today."

The work of gathering material and building the teeth is carried on quietly but persistently, beginning in the lower jaw at the front. There is

very little disturbance of the gums, and one day mother, who has been watching for the event, discovers a gleaming bit of white. The first tooth has appeared and the event is usually celebrated by the family who inspect with enthusiasm the latest arrival.

When the first piece of biscuit is presented to "His Majesty," without hesitation, he knows exactly what to do with it!

Now, who taught these architects to construct these incisors, canines, bicuspids, and molars? The only logical answer is, "God."

When Junior is about six years old, he discovers a loose tooth. You tie one end of a string around the tooth and the other end is fastened to the doorknob. Slam! — and out comes the tooth, but it is only a shell of its former beauty. What has happened?

Evidently, the carpenters are still on their job. They are pushing out the first lot of teeth, and preparing to build the 32 permanent ones. Do they talk to the departing teeth? "Sorry—but you must go—thank you for the work you've done, but we have to replace you with more and stronger specimens. Please hand over your lime salts—we need them."

While they are saying farewell to the first lot,

they are constructing and pushing through the second set which must last for life. Between the 17th and 40th year, the "wisdom" or third molar teeth appear, the last effort of these teeth experts. They now retire from active life.

Inside your mouth is an interesting organ, the tongue. It can get you into plenty of trouble, and may, possibly, extricate you, if sufficiently nimble! You talk because you have a tongue. The air issuing from the lungs passes across two vocal cords in the larynx, causing them to vibrate and sound. These sounds are twisted by the tongue into vowels, consonants, language—an altogether marvelous operation.

Your tongue enables you to taste. The surface is covered with hundreds of taste-buds standing like sentinels waiting to sample anything which may be introduced into the mouth. The front portion specializes in sweets; the sides, sour and salty; and the back pays special attention to bitter substances. The result of their examination is communicated to "Central" who approves or disapproves. If violent disapproval is registered, "H. Q." orders immediate rejection of the offending mass—sometimes even after it has left the mouth and has entered the stomach.

Three sets of salivary glands empty their se-

cretion into the mouth. The olfactory nerves, specializing in odors, detect appetizing aromas issuing from the kitchen. Excitedly, they transmit the news to "H. Q." — "Meat, vegetables and other good things coming — plenty of saliva, please." And your mouth waters! If the food is delayed the first over-supply is not needed but there is always plenty more.

Saliva changes starch to sugar in five seconds. If you want to test this, hold a piece of bread in your mouth for a short time. You will soon taste the sugar.

The act of swallowing is a complex muscular action, begun in the mouth. It is not an accidental disappearance of food which has moved to the precipice at the back of the tongue and slipped over the brink! The food is rolled into a ball, lubricated with saliva and mucus, and then gently pushed down the gullet, which is a muscular tube, ten inches long.

The opening into the gullet lies behind the opening into the wind-pipe, at first seeming to be a strange arrangement. Why not have the gullet in front where the food could pass down without any danger of getting into the wrong passage? If it had been thus constructed, the difficulties

would have been increased. The Divine Architect made no mistakes.

There are three openings which must be closed before food or drink gets into the right place—the gullet, or oesophagus. The large door into the larynx, of course, must be closed. This is managed by placing there a little trap-door man, called "epiglottis," whose job is to push down his cover over the opening, immediately the telegram is received that something is leaving the mouth. Down goes the door, over goes the food, and on to the stomach where it will remain for some hours—unless you are seasick!

Openings into the nose and ears must be closed. The soft palate moves up to accomplish the former, and muscular contractions effect the latter. Fancy your predicament if the Eustachian tubes running upwards to your ears remained open. During the course of your meal, you would discover with alarm that the food was going into either ear!

Chapter Four

WHAT BECOMES OF YOUR FOOD?

IN order to keep the life fires burning, food is the fuel which your body engine uses. As the process of digestion alters the food, heat is generated, and the ashes of combustion are dumped into the garbage-remover, which is the blood stream.

Food must be radically changed so that the billions of tiny cell-people can utilize it. A piece of meat or a salad as it comes to the table would be useless as food. Their contained elements must be made available. Sugars, proteins and fats must be offered in very small amounts, easily obtained.

When the ball or "bolus" of food is pushed from your mouth into the gullet—this can be accomplished even if you are standing on your head—it finds itself in a ten-inch muscular tube, the oesophagus. In five or six seconds, it reaches the entrance to the stomach. The door opens and in it goes to join other portions. The room into which the food is admitted holds about five pints, normally, and is suspended somewhat vertically, rather than horizontally. Inside it is a beautiful bright pink color.

The stomach is a muscular churn as well as a digestive organ. In order to give time for the stomach to work on its contents, it must be closed at the far end. So, here is another gateman, called the pyloric valve, which closes and guards the door into the small intestine. This valve remains shut for a few hours, or until "H. Q." wires—"O. K.—time to continue the food journey—open!"

During the enforced stay in the stomach, many things have happened to the dinner. The food is violently jerked from one side to the other by strong muscular contractions—peristalsis. The gastric juice has been poured out and the Hydrochloric Acid, pepsin, rennin, and lipase, have been getting in their work.

The food has been changed, broken up, partially digested, and made ready for the final operations. Pepsin has split the protein, rennin has coagulated the milk and converted casein to paracasein; lipase has changed the fats. Bacterial growth has been checked by the acid. Meat, flesh, fowl, fish, eggs and milk, have been digested.

Another command from "H. Q." and the pyloric valve opens to permit the stomach contents to gush out into the duodenum (twelve inches

long) the first part of the small intestine. Here the digestive process is continued as a continuous series of marvels take place.

As soon as the interior of the bowel feels the acid food mixture, a troop of messenger boys—hormones—the "secretin" boys, are dispatched from the duodenal glands in a hurry. They leap to the fast moving train—the blood—and in less than a minute have jumped off at their destination, the pancreas or sweetbread. "Well?" says the pancreas. Secretin answers: "Food has just left the stomach—it will be along in a few moments—plenty of pancreatic juice immediately!"

Through a special channel or duct, the pancreas discharges its powerful digestive fluid into the duodenum. When the food arrives, it is bathed in this fluid, and digestion continues. Your meal now is unrecognizable as that which a few hours before entered your stomach. It has been changed into a thick, creamy mixture, called chyme. Millions of little hands are reaching out from the inner wall of the intestine pulling into the food train—the moving cafeteria—the bits of sugar, protein, and fat.

Along the twenty feet of tubing which forms the small intestine, the liquid is pushed by the muscular engines—2,000,000 to every inch of

passage—and the 1½ pints of pancreatic juice, with bile from the liver, and juices from the intestine, known as "succus entericus," working constantly.

The food is kept moving slowly onward, acted on by the five quarts of digestive fluids which are poured daily into the intestine. Of this amount about 4½ quarts are absorbed back into the system and worked over again—another example of Nature's economy.

Pancreatic juice, alkaline and sticky, contains three enzymes — the word "enzyme" meaning "in-leaven," because, like yeast, it causes fermentation. These enzymes are known as trypsin, amylase, and lipase. Assisted by the fluids from liver and other parts, the amazing digestive process is completed and the food-train loaded down with all that the billions of cells require.

This moving-cafeteria system works beautifully. While not literally true, it may be imagined that the tiny bundles of the various food elements are laid out in orderly fashion along the edge of the flat cars which make up the train. Sugars and starches have become "simple" sugars; fats have become glycerin and fatty acids; proteins have been broken up into many forms of amino-acids and certain mineral salts. Soaps,

fatty acids, and glycerol, are carried away as "chyle" to little tubes known as lacteals of the lymphatic system, and into the general circulation by way of the lungs.

The sugars and amino-acids are hustled into a large vein — the portal vein, and carried to the liver for inspection, purification, and storage.

When the food-train leaves the Union Station, which we shall call the heart, it is travelling very rapidly—thirty feet a second. This is much too fast for the cells to grab their food, so that it is necessary to slow down the rate of travel. In the smallest tubes, the capillaries, and lymph channels, where the food is extracted, the train moves only about one inch a minute. The hungry cells have plenty of time to select their meals, and if they wish, to smack their (imaginary) lips!

Throughout this entire intricate series of operations—forethought and planning are evident. Surely, an Omnipotent Creator is needed to account for all these wonders.

Chapter Five

HOW YOUR BODY HEAT IS MAINTAINED

THE body cells must be kept at a temperature of ninety-eight and three-fifths degrees Fahrenheit in order to function properly. A few degrees above or below this means inevitable death.

A chilled cell seems to become paralyzed and helpless in the presence of enemies which, under normal conditions, it could conquer. An extreme degree of fever, likewise, slows down or burns up all activities.

A cell, slightly over-heated, apparently, can offer increased resistance. This is probably the reason for fever caused by infections of various sorts. It is a clever device to give the body additional and unusual power. It used to be thought that fever must immediately be lowered in case of illness. If you are sick, and develop a moderate degree of temperature, you may be thankful. Your body is putting up its best fight.

Today, artificial fever is resorted to for the cure of certain illnesses. In many instances, the results have been phenomenal. It has taken us a long time to learn this secret of the Creator's, as one of His ways of warding off death.

You may be subjected to extreme changes in the surrounding temperature. That is, you may be forced to stay where the thermometer drops low, or where the mercury rises to 120 degrees as in Death Valley. Exposed to a temperature of 30 or 40 degrees below zero, you need more food, more burning of fuel, and possibly, more clothes.

But, suppose the heat is intense, day after day. You are hot—very much so, and afraid that your blood heat is going up. However, the thermometer under your tongue, tells you that the temperature is normal. How has the body managed to keep you so cool internally? How does it get rid of the heat?

Ordinarily, there is some heat loss from the skin by radiation and conduction, but these will not suffice in emergencies. Air issuing from the lungs is always hotter than when it was taken in; also, it contains water—about a pint a day.

The blood stream reaches all parts of the body. It flows through about 16 square feet of skin and about 90 square yards of lung lining. Blood is 90% water, which acts as the transporter and distributor of heat. There are, approximately, 2,000,000 sweat glands scattered over the skin surface—500 to every square inch, except on

the palms of the hands and the soles of the feet, where there are about 2,000 to every square inch. Thousands of miles of very small pipes,—capillaries, are found in the skin very close to the surface, along with many thousands of sensory nerves or telegraph wires, along which go ceaseless messages.

These nerves are always tattling everything that happens, to "Central,"—a steady stream of personal gossip. Now, in Death Valley, they do not like the great heat, and we may listen in to a bit of conversation. "We can't stand this heat, 'H. Q.' Can nothing be done? Why not tell the sweat-glands to get busy. Hurry, please!"

This brings immediate response from "Central" and from two to ten pints of hot water are passed out through the skin in 24 hours. The radiator is cooled and normal temperature is maintained.

H. Q. issues two orders under these circumstances. One, to the sweat glands, and another to the miles of superficial blood vessels. The latter command is for them to enlarge their calibre to permit more hot blood to come to the surface. The skin gets red, as a result, and heat is evaporated quickly.

Animals have not been forgotten either. Take

a hot dog—no, better state it differently—think of a heated canine! He loses hot water from the pads on his feet, while hot saliva drips from his open mouth, with the same result.

In very dry atmosphere, the perspiration may not be visible because it evaporates as quickly as produced, but the ultimate result is the same.

In chapter one, it was stated that there seems to be a heat regulating mechanism in the skin. It may be you are getting cold. You have a shivering spell or a chill. What is the cause? The nerves in the skin know that they are becoming cooled—they fear for what may happen. They send an urgent request to "H. Q." for action. "Can you not shake things up a bit—we are cold?" The answer is the action of the muscles which jerk themselves violently in an effort to produce some heat, and to warn you of your danger.

As Dorsey puts it:

> "Every move we make, every word we speak, every thought that passes through our brain, every beat of our heart, every breath we draw awake or asleep, requires energy. We need about thirty ounces of fuel a day to keep our body machine in good trim. The combustion of that fuel makes just the same amount of heat in our body engines as if burned in any other engine. And all the

while we must run a refrigerating plant or boil over, and a heating plant or freeze to death. Our motor mechanism must be oiled at every point of friction. Our nervous system must be protected, cleaned, and kept in repair. . . . We are fearfully and wonderfully made."

Chapter Six

BREATHING

BEFORE you were born, you derived your oxygen and food from your mother, through an astonishing arrangement whereby the blood of the child comes close to that of the mother—no actual mixing—as baby unloads his supply of carbon dioxide poison into mother's blood, to be eliminated through her lungs. At the moment of discharging the carbon dioxide, oxygen is taken on. Baby's engine must have air to keep the fires burning.

At birth, lungs are solid like liver. No air has ever entered them, but they have large, latent possibilities. They look like complicated sponges, with millions of air sacs, opening into tiny funnels, these into larger tubes, these in turn to still larger, until they all end in the two largest,—right and left bronchi. These are joined to the windpipe.

When baby is born and separated from its mother, who, for nine months has looked after its every need, it must instantly fend for itself. With a loud cry—how welcome this sound is!—it takes in its first load of air. The balloon-like sacs—the lungs—distend as the bellows, moved

by twenty-four levers of bone, do their work. The lungs will never again be deflated. Two pints of air will always be left in the lungs even after forcible expiration. Following a deep inspiration, we can forcibly expel about one gallon of air.

More work requires more fuel; more fuel requires more air. So, when we work hard, we "pant," that is, our bellows work faster and keep up the pace until the normal proportion of carbon dioxide is restored in the little air-sacs.

Obviously, the entrance to the lungs must be kept open. Some contrivance to prevent closure by pressure must be devised. The solution at which the Creator arrived, was to hold the passage open with stout rings of cartilage which are found between the back of the throat and the bronchi, the tube carrying the air being known as the larynx and trachea.

The breathed-in air, rich in oxygen, enters the thin-walled sacs in the lungs. Here it comes into close contact with the maternal stream and the exchange of gases is made.

The chemical, Hemoglobin, in the blood, makes possible the extraction of oxygen from the air. This remarkable substance has such a hunger for oxygen that it grabs it wherever and

whenever it is afforded an opportunity, letting it loose for the use of the working cells whose lives depend on a steady supply. The furnace fires must never be permitted to go out.

Blood containing much carbon dioxide—that is, the blood which has lost its oxygen and is on the way back to the lungs for more, is of bluish color. Fresh supplies of oxygen give it a beautiful rosy hue—arterial blood.

The bellows work about sixty times a minute in the new-born, slowing down to about 40 in the child, and 16 to 18 in the adult. Expired air has lost 5% of its oxygen and gained 4% of carbon dioxide. It is hot and saturated with moisture — water. It takes about two seconds for the unloading and loading process. The blood can make the round trip through the body and back again in less than half a minute.

The air must be warmed before it enters the lungs. The method adopted is ingenious. The chambers in the nose have projecting shelves of bone, with the lining all wrinkled over a multitude of hot pipes,—the blood vessels filled with warm blood. A large surface, therefore, is provided, over which the air passes, getting heat and moisture.

Also, these nasal chambers are provided with

many hairs which act as very efficient filters, keeping out unwelcome visitors that would like to push their way through and possibly do much harm, like flies, or dust, or germs.

Special guard cells are there too, whose business it is to throw out a sticky jelly or mucus for the purpose of gluing together in bundles these dangerous enemies. Then, the force-pumps or muscles of the chest can drive up heavy blasts of air through the back doors into the chambers, throwing out the entire lot in one mighty heave. That is "sneezing"!

This is another example of the innumerable "reflex actions" that are going on unceasingly in your body. The little, watchful sentinels, the nerves in the nose, conscious of the presence of strangers, send along word to "Central" who looks after the situation without delay. Mucus is thrown out, the enemy caught and tied up, and then suddenly evicted without ceremony.

Chapter Seven

YOUR BLOOD

IN 1799 George Washington was bled to death in an effort to cure him. At that time, very little was known about this amazing fluid, which excites inexpressible wonder now that we are acquainted with a few of its extraordinary powers.

An individual weighing 160 pounds has, approximately, four quarts, — a pint for every 20 pounds. If more than one-third of this amount is lost at one time, death will likely result. When the loss is not enough to prove fatal, the former volume and composition is regained in about a week.

Through the microscope we see a pale, yellowish liquid, with two kinds of solid elements called cells. There are the reds, looking like a lot of dumbbells, tumbling over and over in puppy fashion, as they run along inside their pipes. They are red because they contain Hemoglobin, the pink coloring material, because of which we are enabled to breathe. These red corpuscles are what give the men their red lips and pink cheeks. The ladies, it is believed,

have another way of securing the same desired effect!

In a drop, the size of a pinhead, there are about 5,000,000 reds and only 7,000 whites. The red knights—which Grenfell calls the Mounted Police, are born in the snuggest nurseries imaginable. They come to life in the red marrow of the long bones. They have no holidays, and die of hard work in about ten or fifteen days. But they have unlimited powers of birth. They can produce more in ten minutes than there are people on the entire face of the earth—2,000,000,000.

12,000 reds can stand side by side in a space one inch long. If they stand head to tail, only 3,500 of them could be accommodated. They make up about 35% of the volume of the blood and in a spoonful of blood there are about 30,000,000,000, in an adult male about 25,000,000,000,000; a few billions less in an adult female.

As you look through your microscope, you see a white cell, neatly uniformed in his white suit, crawling slowly along, like a policeman taking time on his beat. These white corpuscles or leucocytes are the fiercest fighters in the world and we owe our lives to their bravery and skill.

The liquid portion of the blood is called plasma. It is mostly water, about 90%, but contains a host of other things, food, drugs, chemicals, and many things about which the physiologist would like to know more. There are curious ferments, known as enzymes; the potent poisons manufactured by the ductless glands; in fact, everything needed by the 26,000 billion little workers. They must have food, air, water, raw materials for repairing broken bones and the like, bricks and mortar for building everything in their city.

The blood is their home, their transportation system, with incessantly-running trains always on time, tickets free! Garbage and ashes are dumped here and immediately removed.

Wrapped up in this mysterious fluid, and available for instant use, is the raw material for manufacturing high-explosive to annihilate the enemy hosts which are always attacking. Infinitely curious weapons, to be discussed in a later chapter, are here.

Dorsey gives a list of materials always within reach of the citizens of this huge city:

> "Such inorganic salts as chloride, carbonate, sulphate, and phosphate of sodium, calcium, magnesium, potassium, and iron; such nitrogenous extracts as urea, uric acid, creatinin,

ammonia salts, amino-acids, and phosphatives; many proteins; sugars, fats, lactates, and cholesterol; five or six antibodies, and special substances supposed to be concerned in the clotting of blood."

In each red-blood cell are unnumbered millions of millions of molecules of Hemoglobin. Each molecule is of large size and so complex as to baffle the imagination. Its supposed molecular formula is C758H1203N195S3Fe0218. In other words, each molecule of Hemoglobin contains 2377 atoms and the molecular weight is 16,669. There are only three atoms of Sulphur and one of Iron.

The major part of hemoglobin is globin, a protein. The remaining 5% is iron salts or hematin, with a comparatively simple molecular formula of C34H34N4Fe05.

The blood of all human beings may be divided into four groups, depending on the presence of substances known as isohemagglutinins. The difference between them exists in the presence or absence of the power to agglutinate or clump together the cells of other groups, or to dissolve the cells. This grouping of the blood is very important when, in emergencies, it is necessary to transfuse blood into a patient. If the wrong group is selected, the result might be fatal.

The approximate percentage of people in these different groups is as follows: Group I, 10 per cent; Group II, 40 per cent; Group III, 7 per cent; Group IV, 43 per cent.

The members of Group IV may be used as universal donors, for their corpuscles are not agglutinated by the serum of any other group. Members of Group I may receive blood from any other group, for their serum does not affect the corpuscles of any other group.

Chapter Eight

YOUR HEART

THERE must be some means of driving to every part of the body the precious fluid with its multitudinous supplies of fuel, food, drugs, etc. The tube system of transportation, now so common and so useful in all large cities, was adopted by the Architect. A central power house or pump, was placed in the middle portion of the city, with about 12,000 miles of tubes or pipes running in all directions to insure an adequate service to every district.

The heart is just a half-pound of muscular tissue, about the size of a man's fist. It is the most marvelous pump in the world, exceeding in efficiency anything man-made. It contains no bone, no cartilage, no glands, not much fibrous tissue, and but a moderate amount of fat. It is shaped something like a pear or egg, and lies in the lower and front part of the chest, a little to the left of the mid-line. Its smaller end points downward and to the left.

It has four chambers or rooms, in two stories, an upper and a lower. The two upper cham-

bers are called auricles (little ears), and the lower ones, ventricles (little bellies).

The auricles are really supply-tanks, while the ventricles are the actual pumping chambers. The right ventricle must pump the blood through the lungs only, and so is not so thick and powerful as the left ventricle which has the major part of the work to do. It must send the blood right through the body and is equipped with walls three times as thick as its mate.

The heart is enclosed in a strong bag or sac, known as the pericardium. The inner surface of the pericardium and the outer surface of the heart are very smooth, and between them there is always a small amount of watery fluid, thus preventing friction.

When dying is prolonged and accompanied by much suffering, this watery liquid might increase markedly, giving reality to the Gospel statement that when the side of our Lord was pierced by the Roman spear, blood and water gushed forth. The pericardial space had been entered.

This greatest of all pumps is able to operate for a hundred years without the loss of even a few minutes for repairs; for days at a time, it will carry an enormous overload; it keeps on going although speeded up to twice its normal rate

or more; if its valves leak, it becomes thickened or hypertrophied, thus increasing its strength in order to continue efficient work under a severe handicap.

Normally, in an adult it beats about 70 times a minute; yet, within the limits of health it may vary from 45 to more than 100. As a general rule, the bigger the body, the slower the beat. An elephant's heart pumps very leisurely at about 25 per minute; a donkey's, 50; a new-born baby, 140; a rabbit, 150; a mouse, 175.

If you would give this pump, which contracts forty million times a year, a rest of 20,000 beats some day, lie in bed! The only rest it gets is between beats. After it wrings itself dry, like a woman squeezing out a towel, it has a fraction of a second for recuperation. When you are lying down, it will pump about five pints a minute into the big vessel, the aorta; if you run upstairs, it will do six or seven times as much work—30 or 35 pints.

The amount of energy it generates is staggering. During a period of 24 hours, it exerts power sufficient to lift a two pound weight twelve miles into the air; or, your own body, more than half a mile. In a month, it could lift you two miles above Mount Everest!

The two ventricles, at each beat, do between twenty-five and thirty thousand gram centimeters of work. That is, enough work to lift one pound to a height of two feet. And, remember that the heart weighs only about half a pound!

A Diesel engine is the most efficient motor that man has yet invented. Of the total energy in the nourishment brought to it by the blood, the heart turns into useful work a proportion equal to that which a good Diesel engine gets out of its fuel.

In the Diesel, however, the energy that is turned into heat is largely wasted, while the heat produced by the action of your heart is used in keeping your body warm. Moreover, the Diesel has to be laid up for repairs from time to time, and requires expert attention; but your heart selects suitable materials from the blood and keeps itself in repair while working.

The thousands of miles of pipes which lead from the heart are interesting. The largest is the aorta, about one inch in diameter, connected directly with the heart at the left ventricle; then the branching system of tubes of arteries, gradually getting smaller and smaller, until the smallest of all, the capillaries, are formed. These carry blood to every nook and corner of every hamlet

in the body, and are so small that only one cell can be accommodated at a time.

The arteries are changed into capillaries, then the small veins begin to gather up the returning blood into which all the refuse has been dumped and the load of carbon dioxide. On and on they go, the vessels getting larger, the tiny rivulets emptying into the larger vessels, until just before the heart is reached, the whole supply of venous blood enters the right upper chamber, the right auricle, through two large veins, the venae cavae.

The auricle immediately squeezes its contents into the next ventricle, back flow being prevented by a unique system of valves. A contraction of the ventricle propels the blood into the lungs, where, as previously explained, the exchange of gases is effected.

With red, oxygenated blood filling the left upper room, one more squeeze, and it is in the left ventricle where the final push has to be given. This must be powerful enough to send the contents leaping through the body, — to be back again in about 23 seconds.

The structure of the pipes shows the Mastermind. Examined microscopically, a thin cross-section of an artery reveals three coats of muscle, one over the other. The dense fibers which com-

pose the outer coat, run lengthwise, providing strength to resist undue expansion. This coat is hard to cut or tear.

The middle coat has two layers of fine muscle fibers circularly interlaced; one of these is elastic, while the other tends to contract. The inner coat lining the vessel, is beautifully smooth, offering a minimum of resistance, and no friction to the speeding stream.

This clever construction enables the tubes to expand and contract with every heart beat, and in fifty years the operation has been performed more than two thousand million times!

Chapter Nine

HOW YOUR BODY DEFENDS ITSELF

YOU cut your finger, but you do not worry much. You feel sure the bleeding will soon cease. Why does the flow of blood stop in a few moments? If it did not, certainly, you would soon be dead.

Once again, the mark of Omniscience is seen. The blood itself has been given the necessary power to turn plumber and close the leak. And these plumbers never are without their tools at the first visit to the broken pipe!

The cut nerves in your finger have lost no time in informing "Central" that blood is flowing. Immediately a series of operations have been set in motion by "General H. Q." From some mysterious hiding-place rush tiny blood platelets, probably assisted by the white-coated policemen and quickly the enzyme, thrombin, brings about a sudden change in fibrinogen which transforms it into fibrin,—a mass of small threads or crystals which fill up the hole in the pipe and the bleeding is stopped.

At the same time there is an instantaneous contraction in the muscle of the cut vessel which

lessens its calibre and makes the leak smaller and, so, easier to close.

The enemies which your body has to fight are legion. There are mistakes in diet, faults in environment, and the like. In addition there are innumerable bacterial attackers lying in wait, ready to seize any chance to enter the body, and engage in mortal conflict with our defenders.

The Creator has given your body a defensive mechanism, which, for complexity and efficiency, is superior to anything on earth.

When Adam and Eve were created, it is probable that they were immune to infections; also, it may be that when sin entered, organisms which before were harmless, degenerated and became capable of producing disease.

Parasites are animals that live on or inside another body — the latter known as the "host." Most, but not all, of these are unwelcome guests. Some exhibit a preference in their enemies, and all have their special peculiarities.

> "The little fleas which us do tease
> Have other fleas to bite 'em,
> And these, in turn, have other fleas,
> And so . . . ad infinitum!"

The most numerous and deadly parasites come from the great half-animal, half-plant world, and are called bacteria. They are so small that we

know very little about them except their shape, their manner of reproduction, their staining peculiarities, and their poisonous products.

In 1683, Leeuwenhoek, the Delft lens-maker, a Dutchman, had a curiosity to know what might be seen in the tartar which he scraped from his teeth. Mixing it with water and examining it under his lens, he saw bacteria. 150 years later, Pasteur proved the amazing facts for which he will always be famous. He showed that what was spoken of as "spontaneous generation" was impossible. All life must come from previous life.

In 1876, Koch discovered that anthrax is caused by a rod-shaped germ, and the conception of disease was revolutionized.

Bacteria are vast in number, and varied in form. Some cause disease (pathogenic), some produce ferment (zymogenic), some bring about decay (saprophytic), and some can manufacture colors (chromogenic). Some are rod-shaped (bacillus); corkscrew (spirillum); round-like-a-berry (coccus). Other names are given according to their manner of division and the possession of certain peculiar characters.

One twenty-thousandth of an inch is their average length. The bacillus of influenza is only

half that size, and the germ of infantile paralysis, still smaller. One hundred thousand typhoid bacilli could lie side by side on an ordinary match and it would take fifteen million million to weigh an ounce.

Bacteria move at varying rates of speed. The germ of typhoid fever travels about one-tenth of an inch an hour, or 2,000 times is own length. Others move much more swiftly.

They are amazingly tenacious of life and never die without a struggle. Some can live for hours in boiling water and sulphur bacteria will thrive in a steaming hot-spring where the temperature is never lower than 190 degrees. Some live and reproduce themselves at freezing, while typhoid and diphtheria germs will actually live for several days at the temperature of liquid air—284 degrees below zero.

They exhibit an astounding capacity of reproduction. Pinching themselves in two in the middle, they go on indefinitely bringing forth fresh generations. The germ of Asiatic Cholera can divide every fifteen minutes. So rapid is their rate of multiplication, and so enormous the amount of poison produced, that the victim usually dies within twelve hours.

The air we breathe, the food we eat, the skin

that covers our bodies, are alive with enemies. Surely, an effective defense, constant and strong is needed in the presence of such danger.

INFLAMMATION is the most universal and most important of all disease processes. It may be defined as the local reaction of the living tissues to an irritant.

This reaction has a definite purpose. Its object is to free the body of the irritant and so is a distinctly beneficent phenomenon, even though its manifestations may be disagreeable to the patient.

It was Metchnikoff who showed that the introduction of an irritant into the body, was the signal for certain of the body cells to exert themselves to bring about its destruction and removal.

It was not on the human body that these observations were made, but upon the transparent body of the star-fish larva. Metchnikoff introduced some rose thorns into this lowly organism, and next morning he observed that they were thickly covered with clusters of cells.

The process may be described as the formation of an inflammatory exudate or secretion, the function of whose cells is to devour the invading irritant of whatever nature.

The feature of inflammation which attracts

the attention of the patient, usually, is the change in the blood vessels, especially the small veins and capillaries. After a brief, preliminary contraction, they dilate more and more so that the part soon becomes red and congested, and the vessels stuffed with blood. More blood brings more soldiers. The army must be adequate for defense and attack.

The inflammatory exudate which is thrown into and around the center of hostilities is formed (1) by migrating cells from the blood—the leucocytes or phagocytes (cell-eaters), (2) by the blood plasma or serum, (3) by certain cells contributed by the tissues concerned.

The four cardinal and well-known symptoms of inflammation are heat, redness, swelling, and pain, to which may be added, interference with the function of the part. The increased blood supply and the resultant swelling which causes pressure on nerves, account for all the signs.

Phagocytosis is an almost universal endowment of cell life. By this power the cells of lower organisms absorb their nourishment; by means of it even the most resistant tissues, such as bone, are moulded into shape; dead tissues may be removed from the body; and, finally, it

is the most efficient defense of the body against disease.

In the acute stage of inflammation, the most active fighter is that particular form of leucocyte which has in its interior a number of condensed portions of tissue, known as nuclei of different shapes. Hence the name it bears—poly-morpho-nuclear leucocyte. It is as powerful as its name would indicate. It approaches the bacterium, pushes out protoplasmic processes or feet which are known as pseudopodia (false feet.) By means of these potent weapons, it engulfs its prey and digests it by dissolving it in a strong digestive ferment which it manufactures for the occasion.

Vast numbers of these leucocytes can be furnished when there is need and it can readily be seen what remarkable defenders have been given your body. When a surgeon contemplates an operation, very commonly he examines the blood to see whether or not the white blood corpuscles are increasing rapidly. If such be the case, it is very strong indication that the infection is dangerous and an abscess may be forming. The policemen are bringing up reinforcements for the battle.

The contents of an abscess are made up large-

ly of dead leucocytes, the brave fighters who have given their lives to save yours. There are many features of great interest which might be discussed in this connection but only the broadest outline has been given to reveal something of the skill of the Creator in thus equipping every body with its own remarkable weapons of defense.

Some fortunate individuals come into the world endowed with a natural defense against certain diseases — natural immunity. Others are compelled to develop this—acquired immunity. These terms, however, are only relative, as everyone has more or less power of resistance to the invading micro-organisms. The nature of this strange power, is very little known.

One attack of smallpox gives a life immunity from smallpox. Vaccination will do the same thing, but may have to be repeated. Various methods of inducing immunity are used. Into the body may be introduced live virulent bacteria, less virulent bacteria, dead bacteria, bacterial secretions, or bacterial products from broken-down bacteria. In the presence of these poisons, the blood is able to manufacture what is necessary to protect itself.

Any foreign protein element in the blood

stream is an antigen. The introduction of antigen sets up immediate activities in the blood; various substances appear as if by magic, all tending to prevent death. The process known as inflammation is what occurs when any of these enemies gain entrance. If the wound is superficial, or on the skin, we notice that the surface is red. This indicates that "H. Q." has sent reinforcements of blood to the area to destroy the enemy at the point of entrance, if possible.

The blood itself is the scene of immensely important changes. At least four kinds of protective or curative substances, called antibodies, may be produced.

The first of these is OPSONIN. This seems to give an appetizing flavor to the germs, so that the phagocytes, your fighting policemen, find them tasty morsels and go after their meal greedily. Also, this antibody seems to give new vigor to the army of police, so that instead of engulfing them singly, the germs disappear in bunches. The leucocytes are "fighting mad"!

The second antibody is called AGGLUTININ because it drives the bacteria together in herds, thus making it possible to slaughter them wholesale.

The third is PRECIPITIN which forces the

germs to settle down or precipitate when held in solution; number four is LYSIN. This dissolves the bacteria and ends their existence quickly.

The blood knows what kind of a germ is causing the trouble and the nature of the specific cure which is necessary. It makes no mistakes. That is, if a typhoid bacillus is the cause of the disease condition, an antitoxin for diphtheria would be no use. Each kind of infection brings the right remedy provided by the blood.

Lobar pneumonia is a common and fatal illness. It often attacks adults in vigorous health and runs an interesting course. The patient will have a crisis—he will be on the way to recovery or certain death on the 7th or 9th day, usually about the latter time.

In the early days of his practice in Northern Canada, this writer had some thrilling experiences, travelling across miles of deep snow on snowshoes, carrying grips in either hand, operating in log-houses, a life which was anything but monotonous.

Many cases of lobar pneumonia came under his care. The patient—a father, let us say—has been very sick for several days and the expected crisis approaches. The family are anxious and fearful. "Will you stay with us tonight, doc-

tor? You are looking for a change and we do not like to be alone—father is so very sick!"

About midnight, possibly, my faithful horses take me into the country and to the home of the sick man. He is desperately ill. Fever is high, pulse bounding, respirations rapid and labored. His color is bad, — cyanosed because of lack of oxygen—one or both lungs blocked. He wanders in delirium and all that medicine can do has been tried. We watch and wait.

One o'clock in the morning. Two o'clock. Tiptoeing into the room, the friends look at him, and whisper: "Will he get better, doctor?" "Can't say—the crisis has not arrived." The minutes pass slowly, and it may be that the first streaks of dawn are coming in the Eastern sky when we see a change. Beads of perspiration appear on the forehead. The skin is moist and not so hot. The heart action is better, the respirations not so difficult; the delirium is less and presently restful sleep comes. In two or three hours, he wakes to exclaim: "What's the matter? I'm hungry." He will recover.

What a strange thing has happened? In the Great War, it was learned that before a drive over the top, great quantities of high explosive had to be accumulated in the rear and fired off in a tre-

mendous barrage before the zero hour, in order to smash the defense of the enemy.

A short time before this crisis, a tiny pneumococcus germ somehow forced an entrance into the blood stream of my patient. Boarding the train, he demands to be let off at the lung, the only station that interests him at this time. Arriving at his destination in a few seconds, he proceeds to "dig in." A policeman comes on the run, takes in the situation at a glance, and hurries back to his captain. "Say, Cap, there's a miserable pneumococcus over there in the left lung, and he looks to me like a bad one. We've got to get busy!"

Soon, there is immense activity in the defending army. Urgent calls are sent to all parts of the body. The Captain's orders are obeyed without question. "Bring up all available reserves —we must increase our forces to the highest point. It is life or death."

Feverishly they work. Countless millions more fighters arrive and the pile of explosive grows apace. The sick man is worse and the outlook is dark.

A worker, fearful and hesitant, after six or seven days, takes time off to interview the Chief: "Cap, the boss seems to be dying—we've quite

a lot of ammunition. Why not take a chance and fire it off?" But, his suggestion is ill-advised. "I'm giving the orders here. There's **NOT** enough explosive — back to your work!" And, with his imaginary tail between his imaginary legs, the little policeman returns to his job.

The Captain knows his business and as I sit beside the bed, the command goes out: "Fire, boys!" The enemy is overwhelmed, the crisis is over and there is rejoicing.

This strange and marvelous ability of the blood to accomplish such results is a comparatively recent scientific discovery. It was in 1629 that Sir William Harvey discovered the circulation of the blood and that the life principle resided therein. Until then, it was believed that the air was the important thing. And yet, Moses recorded the same great truth in Leviticus 17:11 and 14: "The life (principle) of the flesh (body) is in the **blood.**" There is no explanation but that God was the Author of that statement.

There is another blood, far more amazing than that which courses through the body of man. It is the PRECIOUS BLOOD of Jesus Christ. Redemption through His blood, shed on the Cross of Calvary, is the great theme of time and eternity. We are "not redeemed with corruptible

things as silver and gold, but with the precious blood" (I Peter 1:9). Not His life, not His example, but His death saves us. Friend, have you been touched by this life-giving fluid?

Chapter Ten

YOUR DUCTLESS GLANDS

NO two individuals are exactly alike, and many and strange have been the explanations offered to account for the differences. Of recent years, the ductless or endocrine glands have been studied with great interest. They are comparatively new to science, but, already, the discoveries made in regard to them are so astounding as almost to pass belief.

They are called "ductless" because they have no ducts to convey their products to their destination. They are emptied directly into the blood stream which flows constantly and abundantly throughout their substance, carried in innumerable, small, thin-walled vessels. They manufacture chemicals known as hormones, which may be thought of as messenger boys, whose duty is simply to carry messages to various parts of the body. They give orders but do no work themselves.

Barker describes their widespread operations as follows:

> "More and more we are forced to realize that the general form and the external appearance of the human body depends, to a large extent, upon their functioning. Our stature, the

> kinds of faces we have, the lengths of our arms and legs, the shape of the pelvis, the color and consistency of the skin, the quantity and regional location of our fat, the amount and distribution of hair on our bodies, the tonicity of our muscles, the sound of the voice and the size of the larynx, the emotions to which our "exterieur" gives expression—all are, to a certain extent, conditioned by the productivity of our . . . glands. We are, in a sense, the beneficiaries and victims of the chemical correlations of our endocrine organs."

These facts are all the more puzzling when we learn that these important structures are among the smallest in the body. Some of them are no larger than peas.

When they function normally, our attention is not attracted to them. Their presence is not suspected. But, let one of them go wrong, and the results are varied, startling, and may be fatal.

According to their working, one will be normal in height and weight; or an eight-foot giant; or a midget the size of Tom Thumb; he may be extremely fat or very thin; of average mentality, or a hopeless idiot, or a brilliant genius. To them are attributed innumerable other characteristics, more or less striking.

These insignificant pieces of tissue turn out the most powerful drugs known. Eight of these

drug-factories operate in your body, possibly more. There are the pineal and pituitary glands, hidden away in the brain; the thyroid and parathyroids in the neck; the thymus, behind the breast bone; the adrenals, sitting on top of each kidney; the pancreas; the gonads or sex glands. The small intestine secretes a hormone, and there is a suspicion that the stomach and heart may produce these remarkable chemicals.

The discoveries, being made in this realm, have given rise to the belief that mankind is at the dawn of a new era in medicine.

Every second of every day, every cell of the billions in your body is being drugged with poisons so potent that the amount which might rest on the point of a pin, constitutes a dose. In other words, all the cells are confirmed drug addicts. Take way their daily supply and there is immense disorder. Let one set of glands falter—the entire family rush to the aid of the unfortunate ones, in a mad effort to assume the unaccustomed job.

Some hormones increase the rapidity of your heart action; others slow it down. Some raise blood pressure; others lower it. The rate of your breathing, the pace of your digestive processes, the clearness of your vision, the strength of your

bones, the alertness of your brain, the nature of your disposition, are all affected.

There is some resemblance to those drugs taken in with your food. These are called vitamins. If vitamin A is missing, your eyes go bad; is B is absent or reduced, your nerves go bad; if C is not sufficient, the dentist will get you; if D is less than normal, bone troubles are likely.

But, compared to the hormones of your ductless glands, vitamins seem commonplace. Some hormones are so powerful that one thirty-thousandth of a grain is an effective dose. And, these small doses are necessary to life, although a much larger amount would kill speedily. Who regulates the amount? Could anyone but God be responsible for this?

The Thyroid

is the best understood of all the ductless glands. It gets its name from its fancied resemblance to a shield. It sits astride our Adam's apple. It varies according to age, and also in individuals. It is relatively largest before birth, and its weight at birth, in proportion to body weight, is as 1 to 300. At the end of the third week, as 1 to 1160, and in adult life, as 1 to 1800. It is generally larger in women than in men—reason not known.

It consists of two equally developed lobes or wings, about two inches long by one and a quarter inches broad. A narrow bridge of tissue connects the two parts in front of the wind-pipe. It weighs from one-half to two ounces, is reddish brown in color, and is very richly supplied with blood vessels. Three and a half times its own weight of blood flows through it every minute.

It is made up of little hollow balls, called follicles, filled with a thin, glue-like substance known as colloid, containing about one-half of one per cent of Iodine. The contained hormone, thyroxin, has 65 per cent Iodine. Only the thyroid secretes thyroxin, the important part of which seems to be Iodine.

It may be that there is no life apart from Iodine. Certainly, normal human life is not possible without one one-hundredth of a grain of thyroxin daily. It has been estimated that all that stands between intelligence and imbecility is three and one-half grains of thyroxin.

Thyroxin is the body pacemaker, determining the rate at which the human engine shall run. In other words, it controls metabolism, which means the rate at which the body burns oxygen and throws off carbon dioxide. Under its influence, the body burns up more quickly, and the symp-

toms may be very distressing—high blood pressure, rapid pulse, lax and moist skin, nervousness, and protruding eyeballs, hence the name, "Exophthalmic."

The term used to designate enlarged thyroid gland is goiter or Derbyshire neck. This condition is found in every inhabited part of the globe, but is more prevalent in the so-called "goiter belts." These belts in which from 20 per cent to 90 per cent of the children suffer from goiter, are found in Switzerland, Austria, Germany, and parts of England; on this continent, in the region of the Great Lakes, the St. Lawrence River basin, and the Pacific Northwest.

This abnormality was known in ancient times, but only within the past two or three decades has medical science begun to understand the functioning of the strange gland.

There may be simple enlargement without any poisoning of the system; the enlargement may or may not cause pressure symptoms. An over-active gland throwing increased amounts of chemical into the blood, sets up toxic or exophthalmic goiter, sometimes called Graves' Disease.

Since the beginning of the century it is probable that between one and two million goiter operations have been performed. In time, however,

it is possible that most goiters will be prevented, when we know and are able to supply that which the thyroid is attempting so energetically to provide.

A tadpole with its thyroid removed, never becomes a frog—it remains a tadpole. A tadpole fed on thyroid extract, becomes a frog in two weeks instead of taking a year as usual. But, under these conditions, the frog is only the size of a fly.

Children whose thyroid glands have been removed, atrophied or otherwise injured, are known as CRETINS. They are heavy-featured, slobbering, idiotic dwarfs. Their skin is dry and hairless; their sex-glands undeveloped; temperature subnormal; they are pot-bellied, and have a small pelvis; with limbs short and thick.

Adults with a corresponding condition suffer from MYXEDEMA. Their skin is white, dry, rough, thick, and hairless; they are obese, with lowered temperature and metabolism; the pulse is slow and weak, and mind dull.

Cretinism and myxedema respond marvelously to treatment with thyroxin. The change is miraculous and startling.

In the goiter belts, the water is usually deficient in Iodine. A small amount of Iodine daily, taken by the children is usually sufficient to pre-

vent any disturbance. Many people possess a thyroid which does not function quite normally and all that is needed by these individuals is a small amount of thyroid extract in daily doses.

Behind the thyroid and in close contact with it, are the PARATHYROIDS, usually four, but varying in number, either more or less, in size, and in position. They are very small, about the size of grains of wheat, reddish-brown in color, and slightly harder than thyroid tissue. Their combined weight is only about two grains or one two-hundredths of an ounce.

Small and apparently insignificant as they are, death, in from twelve to forty-eight hours, with acute muscular convulsions, follows their removal. In some mysterious way, they have to do with calcium metabolism. If this is interfered with, the bones become brittle and break, the skeleton shrinks, and ultimately death ensues.

From animal parathyroids, Dr. Collip has prepared a hormone which he calls parathyrin, and which he believes to be the substance secreted by the human gland. It is this drug, apparently, which steadies the stimulation of the muscles by the nerves. When it is absent, there is irritability

and muscular twitching with spasms and convulsions.

It may also play a part in the digestion of meat proteins, keeping the formation of toxic products at a minimum. Children suffering from deficient parathyroids have muscular spasms after eating meat, and are of an irritable disposition.

The Thymus Gland

lies just under the upper end of the sternum or breast bone. Well developed before birth, it increases in size until puberty when it begins to lose its character, and becomes connective tissue, lymphatic tissue, and fat. It seems to secrete a hormone which restrains the development of the sex glands. Of four hundred idiots examined post-mortem, three hundred showed no sign of this gland.

Pigeons from which the thymus has been removed, lay eggs without shells; if fed thymus extract, they lay eggs with normal shells. It weighs about half an ounce at birth.

The Adrenals—or, Suprarenals

These are two in number, one sitting on the top of each kidney, like a cocked paper hat worn at a New Year's celebration. Each gland is about two inches long and one inch wide, and consists

of two parts, an outer covering, known as the cortex, and an inner core, the medulla.

They are exceedingly well supplied with blood, seven and a half times their own weight passing through them every minute.

They manufacture adrenin or epinephrine, the deadliest poison in the body. This hormone was the first of the endocrine secretions to be isolated; Abel discovered it in 1897 and in 1908 chemists were able to produce it from a coal-tar derivative.

Normally your blood contains about eight milligrams of adrenin, or about one part to one thousand million. This minute portion, necessary to life, must, obviously, be regulated with meticulous exactitude. Who, if not God, could be the Great Regulator?

It is distinctly an emergency gland. Compelled to run for your life, you can develop undreamed-of speed, if your adrenal gland spurts into your blood stream an extra amount of adrenin which gives your muscles extraordinary power. You will then know the meaning of "running like a scared rabbit"!

It will prepare you not only for flight but for fight, if this is necessary. Under certain dan-

gerous conditions you become a veritable Samson, performing surprising deeds of valor.

Blood is drawn away from the organs of digestion, and sent to the heart, brain, and muscles. For extra exertion, muscles require an additional amount of sugar, the great energizer. Reserve sugar is stored in the liver, which acts as a sugar-bin. In a fraction of a second, the adrenalin causes the liver to release a supply of glycogen into the blood stream where it is utilized instantly.

In humans, adrenin is found in the interior or medulla of the gland; certain varieties of toads have it in their skin. In New England, a Toad Ointment used to be prepared according to the following directions given by Abel. It was said to be useful in sprains and rheumatism!

> "Four good-sized live toads; boil in water until very soft; take them out and boil the water down to one-half pint; add fresh-churned, unsalted butter, one pound, and simmer; at the last, add Tincture of Arnica, two ounces."

Upper Amazon toads have two strong poisons in their skin-bufagin as well as adrenin. The natives prepare from this a poison to tip their arrows, so powerful that a deer dies in a few minutes from the effect.

The adrenal gland secretes another powerful

drug, cortin, in the cortex or outer shell. When this is lacking, Addison's Disease results, an illness marked by wasting, anemia, great muscular weakness, while the skin assumes a peculiar bronze color. In this condition, injections of cortin have proved curative.

This gland, then, is responsible for two very important chemicals without which life would be impossible, — adrenin and cortin. Adrenalin has been used many times during the past few years to revive apparently dead persons, when injected into the heart muscle. Its mysterious and tremendously powerful action is known only to Him who originated it.

The Pituitary Gland

is probably the master-gland of the body. About as big as the tip of your little finger, it weighs less than one-fiftieth of an ounce, and is housed in a small cavity in the base of the skull, given the name of "sella turcica," or Turk's saddle, from the shape of the pocket in the sphenoid bone which holds it. It is as near the center of the head as possible, and so in the position of maximum safety.

It has two lobes—some say three, an anterior, a posterior, and possibly, a small portion between these. It is the body's most interesting drug-

factory; it prepares eleven different hormones and two others are suspected. It seems to have some connection with almost every one of the bodily functions.

Hanging by a slender stalk from the base of the brain, it sits in its half-inch protected chamber like the officer who directs the fire from the armored compartment in the conning tower of a battleship.

From the front part of the gland come seven distinct hormones.

1. The growth hormone, known as Antuitrin G. This seems to be closely related to growth in connective tissue, cartilage, and bone, as well as to sex-gland activity. The long bones of the body take their orders from these messengers until normal height is reached. This hormone ought then to think of retiring from active service, but, occasionally, continues to urge bony growth with the result that a giant is produced, seven, or eight feet, or more in height.

In other cases, they decide to knock off work with their job barely begun, and then we have a midget. But, by far the great majority of men and women who have ever lived on earth, have been between five and six feet tall, which is the best for all practical purposes. The problem

which insistently demands solution is,—who or what controls the action of this growth hormone? Is there any answer but, "God"?

2. A sex hormone known as Prolan A.

3. Another sex hormone — Prolan B — this one, a recent discovery. During pregnancy these are greatly increased and their presence in the blood provides a basis for the Aschheim-Zondek Test, by which this condition may be diagnosed.

4. The "mother-love" hormone, Prolactin, also called the lactogenic hormone, because it controls the secretion of the mother's milk. It has some strange properties.

Dr. Oscar Riddle of the Washington Carnegie Institute, working in the Cold Spring Harbor laboratory, performed some apparently magical tricks with Prolactin and his hypodermic needle. After three or four injections, hens began to brood. Two to four days after the first injection they began to cluck. A day later they were nesting.

Three or four doses caused a proud rooster to stop his crowing and strutting; instead he went about like a clucking hen that had just laid an egg.

A mother rat, similarly dosed, ceased attack-

ing and eating baby chicks, and proceeded to cuddle and protect them as though they were her own babies. When they strayed away, she retrieved them, carefully picking them up in her mouth, and bringing them back to the nest.

5. A hormone which influences the action of the thyroid gland.

6. One which acts on the adrenal glands.

7. This one is intimately associated with the action of the pancreas.

From the posterior part of the pituitary comes pituitrin, used in obstetrics and a powerful stimulant to uterine muscle. It is possible that there will yet be discovered other hormones from both portions of the gland.

The Pancreas

is an important member of this august endocrine family. It is the great regulator of sugar metabolism. Scattered throughout the pancreas are many small areas, composed of cells entirely different from those forming the main part of the gland. These little areas are called the ISLANDS OF LANGERHANS and secrete insulin, about which the world has heard so much during recent years.

In 1922, Dr. F. J. Banting and his associates at the University of Toronto, isolated insulin. It

proved to be the gift of life to millions of sufferers from diabetes. Two million men and women in the United States are now living useful and happy lives, who would be dead or dying had insulin not been discovered.

Insulin is not a cure for diabetes. Given regularly, in proper dosage, it does the work of the pancreas. During normal digestion, sugars and starches are converted into a very simple form of sugar, known as glucose. This is absorbed by the blood-stream, and carried to the liver where it is changed back into a simple starch, called glycogen, and stored in the liver.

In the earlier part of this chapter, reference was made to the action of adrenin during an emergency where extra muscular exertion is required. In response to the demand of this hormone, adrenin, the liver immediately converts some of its glycogen into glucose, which is projected into the blood and on to the muscle, where it is burned or oxidized with the aid of oxygen, the transaction furnishing the necessary energy for this special occasion.

But just as the explosion of gasoline in an automobile cylinder requires an electric spark to set it off, so there is needed a spark to insure the combustion of glucose. Insulin is this spark.

In this ten-inch long pancreas, weighing three and one-half ounces, are scattered from two hundred and fifty thousand to more than a million of islets of Langerhans. If they fail to send insulin into the blood, the combustion spark is absent; the muscles cannot burn up the sugar and it collects in the blood—diabetes.

Deprived of glucose as a fuel, the muscle is compelled to use up the fats and proteins of its own tissue. Consequently, the individual loses weight and strength.

This consumption of fats and proteins causes the accumulation of waste products in the blood, with coma and death, as the inevitable end.

But, today, the victim of this disease carries his bottle of insulin and his hypodermic needle with him, injecting this veritable "elixir of Life" whenever needed.

The Pineal Gland

is no larger than a grain of wheat, and lies high up in the base of the brain, behind and above the pituitary. By the 7th year it is well developed, but then begins to shrink and gradually degenerates into small particles of phosphate and carbonate of lime, known as "brain sand."

Its function is uncertain, and its hormone has not been isolated, but it is thought to promote

early physical growth and to retard sexual development.

Descartes believed it to be the seat of the soul, while evolutionists are fond of affirming that it was at one time a third eye looking straight to heaven through a hole in the top of the skull!

These small bits of tissue with the amazing powers so briefly suggested in this chapter, were formerly called "vestigial organs," — useless remnants of an alleged animal ancestry — by ardent evolutionary advocates. Now, they are known to possess the most astonishing qualities known to science. How the Supreme Creator managed to incorporate in something the size of a wheat grain, the powers which excite our imagination to an incredible degree, remains an inscrutable mystery. No speculative evolutionary hypothesis will suffice as an explanation of these wonders.

Chapter Eleven

YOUR ORGANS OF SPECIAL SENSE

THESE are so named because they convey special sensations to "Central" who interprets them. Expressed in another way, their messages, over their system of nerves or wires, are in code; the expert at the top holds the key to the cipher, and passes the news on to "you."

These senses are those of seeing, hearing, smelling, tasting, and feeling. Through their exercise, we become acquainted with the world about us, and with one another. The centers for sight, hearing, and smell, are located on the cerebral surface, but the home of the taste expert is not so well defined.

Sense of Touch

Scattered over the entire surface of our skin, are the endings of countless sensory nerves. It may be that the code expert for touch resides in the nerves themselves. At any rate, the skin is a marvelous receptor, and certain ranges and kinds of stimuli excite special nerve endings, rather than special organs.

One group of these nerves is sensitive to touch and mild degrees of temperature; another group

detects pressure, pain, heat about 113 degrees, and cold below 68 degrees. In the first group, sensation is felt as though it belonged to the objects, in the second, as if on or in the skin.

With your fingers you do most of your feeling. Therefore there are some special devices to make them more efficient. The skin of the finger-ends is thrown into minute ridges, which form loops, spirals, and arches. In no two individuals in the world do they make the same pattern. Because of this, finger-print identification is infallible.

In the working of this sense is seen constant reflex action. You may be gazing at an elephant in the circus, as he stands quietly playing with his bundle of hay. Suddenly his ridiculously tiny tail gives a vigorous sweep and he turns his head to look at the phenomenon. What has happened?

The tail of the pachyderm is well supplied with sensory nerves — those bearers of all the news items to Central. A fly lighted on our elephant's tail a moment ago and proceeded to tickle it. The message was not long in reaching Headquarters. "Say, Chief, something's on our tail — shake it off, please." "H. Q." obligingly responds with an abrupt order to tail mus-

cles. Flip! goes the tail, and the offender is removed therefrom, while the mammoth resumes his meal.

Fortunately for us, Central never sleeps, so that all messages are received promptly and acted upon without delay. These sort of messages to Central travel at the rate of 426 feet per second.

Sense of Smell

All objects having an odor give off very fine particles. In your nose, high up at the top where the smell machine resides, there are many small cells from which wires or nerves pass right through the bony ceiling, which is the floor of the skull. These wires bear hairs of extreme thinness.

The small particles thrown off from the odorous material, bang into the hairs, causing them to vibrate like the prongs of a tuning-fork.

There is always moisture in the nasal cavity—if it were absolutely dry, you could not smell—and this dissolves the chemical which comes with the odor. Along to Central goes the message. Arriving there, as Grenfell puts it, a picture of the smell is made on the records of the central office. The record offices are called "Memory." They will last as long as Central. That is why, when you have once smelled violets, you never

forget — the record has it. If the records were destroyed, you could not distinguish between the odor of a rose and a foul drain.

So acute is this amazing sense that we are able to detect one eighth-millionth of a grain of musk, and one four hundred and sixty-billionth of a grain of mercaptan, which smells like garlic. In animals, it is still more sensitive.

Sense of Taste

This is in the tongue. Small and numerous taste-buds stand up on the surface of the tongue like an army of sentinels. These taste-buds receive their stimuli from dissolved particles. The tip of the tongue, is chiefly for sweets; the sides for sour and salty; the rear portion for bitter things. Fine distinctions of taste are made possible through the help received from the olfactory nerves of smell. Taste and smell work together. As the messages are conveyed to Central, they are sorted and interpreted for your approval or disapproval.

Sense of Hearing

An elaborate system and complicated apparatus are required to enable us to hear. There are many parts to this.

a. An external ear, shaped like a trumpet to

assist in catching and collecting the waves of sound.

b. A tube leading into the head, from the base of the outer ear. It has curious folds to conduct the waves.

c. A thin membrane like the cover of a drum, stretched across this passage at the bottom of the tube, resting upon a bony rim.

d. A chain of three, tiny, movable bones, the smallest in the body, — malleus, incus, and stapes (hammer, anvil, and stirrup). These are infinitely curious in shape and situation, and make contact between the membrane and the internal parts of the skull, where the more complex portions of the hearing apparatus are situated. The drum touches malleus, malleus lies against incus, and incus rests upon stapes. The latter bone, by the foot-piece of the stirrup, fits into an oval window in the side of the inner ear. As the bones vibrate, waves are set up in the fluid filling your inner ear.

e. The hearing part of your inner ear consists of a small canal, larger at one end than at the other, coiled up into a form resembling a snail shell, or a very small musical instrument, the whole coil being only one-half inch across. In shape and form, the cavities resemble musi-

cal wind instruments, being spirals or portions of circles.

f. The most important parts,—those which have to do with actual hearing—are two sets of rods, varying in length and numbering about 10,000 in each ear. In addition, there are two sets of hair cells, more numerous than the rods, and of different lengths. The auditory nerve has thousands of fibres passing between and around the rods and hair cells.

g. A tube, known as the Eustachian tube, running from the back of the throat to each internal ear. These maintain even air pressure on both sides of the drum.

h. The Divine Sculptor has hewn the entire labyrinth out of the hardest bone in the body.

The ear is a receptor for sound waves or vibrations, and, normally will respond to vibrations of about ten octaves, from forty feet to one-half inch in length, and from 30 to 30,000 per second, in number. Within this range about 11,000 different pitches may be distinguished. It is probable that the rapidity of a sound wave has definite relation to the length of the rods and hair cells affected. The pitch of the sound you hear depends on this relation.

Exceptional persons are sensitive to vibrations

as slow as twelve and as rapid as 50,000 per second.

A sound wave will travel 1,100 feet a second, just snail's pace, when compared to the 186,000 miles covered by a ray of light in the same length of time. When a sound wave strikes the outer membrane or drum, this vibrates, and the three bones, malleus, incus, and stapes, move in unison, carrying the vibration onward to the inner window and the fluid in the internal ear.

It used to be thought that certain electrical changes were induced in the sensitive cells when affected by sound waves, and that these changes stimulated the nerve of hearing, carrying the sound impression to the brain.

Recently, certain scientists, notably Drs. A. J. Derbyshire and H. Davis of the Harvard Medical School, have brought forward the idea that the sensory cells in the inner ear set free a chemical which in turn stimulates the fibres of the auditory nerve.

The hearing "Central" sits on the brain cortex and interprets to you the sounds which reach it. We are able to judge between harmony and discord. One wonders what an expert "Central" for hearing has to say about the cacophony of

discord which it hears when listening to some modern jazz.

Sense of Sight

The eye is the most wonderful of all the special mechanisms. It does its work under the influence of intangible rays of light; just how these affect the eyes and enable you to see, nobody knows.

Its great importance necessitated all kinds of safeguards and devices. It was "set" in the upper and front part of the head, in the look-out position, where it can function most effectively. It is protected by the overhanging supra-orbital arch of the bone, and placed slightly back from the surface, where it is not so easily injured.

Eyebrows also have a protective value, and shed perspiration down the temples, instead of permitting it to get into the eye where it would cause irritation.

The movable eyeball is placed in a beautifully constructed socket of seven bones, dovetailed together with exquisite accuracy. Its movements are controlled by six muscles, one of which is actually slung over a pulley. Would evolution be equal to designing and constructing such a contrivance as this?

The eyelid shows God's care. It defends the eye from injury, wipes it, and closes it in sleep. The cornea which forms the anterior one-sixth of the eyeball is a marvel of construction, with its five distinctly marked layers from without inwards. This extremely sensitive portion must be protected from dust and friction. Therefore it is not surprising to find a unique watering system has been installed; the lachrymal gland for secreting a constant supply of soothing, briny liquid, occupies a position at the upper and outer part of the orbit. A canal to carry off the excess of fluid has been placed at the inner side of the eye, and leads downward into the nasal cavity. The winking movement tends to sweep the tears towards the inner part of the eye and into the canal. An oiling or lubricating system has been provided, and even a delicate filter for dust is seen in the arrangement of eyelashes springing from the rounded anterior lid margin, and placed in rows with a general curvature away from the cornea. All these refinements speak of Divine foreknowledge. The lachrymal solution not only cleanses the eyeball but keeps the nasal cavity moist. This is a necessity for the functioning of the olfactory or smell nerve. The odorous particles which enter must be dissolved before they can be detected.

The eye is often likened to a camera. Behind the transparent cornea is an automatic shutter, the pupil, which is a circular opening in a screen or curtain, the iris, hanging in front of other structures. Through this aperture light enters, the pupil increasing and decreasing in size according to the need of the movement. A bright light causes contraction, so that the sensitive and vital parts inside are protected; reduced light results in dilation so as to permit the greatest possible amount to enter.

Behind the pupil is another automatic part, the lens, which has the power to change its shape, depending on whether you look at objects near or distant. When middle age is reached, the lens begins to harden, and its action is faulty. Then, another and artificial lens is needed and is provided by the oculist.

These two, the pupil and lens, adjust themselves with amazing speed and accuracy. Their beautiful coordination under all conditions, is an example of God's perfection as a Builder.

Behind the lens is a chamber filled with a clear jelly, the vitreous humor, and lined with a black membrane like your camera. In this back portion we find the retina, which is really part of the brain, spread out very thinly. It corresponds to

the film of your camera and receives the image which falls on it. Your camera film can be used only once and it is done. But the retina receives new pictures and sends new impulses to the brain as frequently as ten times a second, each picture clear and distinct. Images can be transmitted as frequently as 16 times a second, but at that speed Central interprets them only as a blur, unless they are of such a nature that they will blend into a moving picture.

This power of coordination between the human eye and the corresponding part of the brain has made possible the modern moving-picture industry.

The eye is made for light and light is the impulse which operates the eye. The eye is the outer end-organ of the optic nerve coming direct from the brain. It is specialized to receive certain stimuli, which, carried to the brain, give the sensation of sight.

The eye is the receiving apparatus for certain kinds of physical energy,—ether waves. Countless ether waves are constantly impinging on your retina but it responds only to those with a rate of 400,000,000,000,000 (four hundred thousand billion) to 800,000,000,000,000 (eight hundred thousand billion) per second.

Light waves travel 186,000 miles a second, and vary from 1-30,000th to 1-60,000th of an inch in length. Within this range the human eye can distinguish about 230 pure spectral tints.

Ultra-violet and X rays vibrate much more rapidly and are therefore beyond human vision. Waves of a speed of about 400,000,000,000,000 per second are those which give the red color of the spectrum; also, they may be perceived as radiant heat. Beyond this are the six octaves of the infra-red, and beyond the infra-red, are the long, slow, electric, Hertzian waves.

What happens when you see something? Light waves are reflected from the object through the cornea, pupil, lens, humors and reach the nerves or telegraph wires, hundreds of thousands of them, which carry the message to the "Sight Central" of the brain, a spot in absolute darkness. There, everything is interpreted for you.

In "God and the Cosmos," Prof. Theodore Graebner summarizes some of the remarkable evidences of design presented by the human eye. He writes:

> "The human eye, once its wonders have been appreciated, remains an outstanding example of design . . . its marks of design are abundant and overwhelming. . . .
> In order to see anything clearly, it is neces-

sary that an image or picture should be formed at the back of the eye, that is, on the retina from whence the impression is communicated to the brain.

The eye is an instrument used for producing this picture, and in some respects, is very similar to a telescope. In both the eye and the telescope rays of light have to be refracted, so as to produce a distinct image; the lens and the humors in the eye effect this. The different humors through which the rays pass, prevent them from being split up into different colors.

In the next place, the eye has to be suited to perceive objects at different distances varying from inches to miles. This is accomplished by altering slightly the shape of the lens, making it more or less convex.

A landscape of several miles is thus brought within a space of half an inch in diameter, although the objects it contains, at least the larger ones, are all preserved, and each can be distinguished in its size, shape, color, and position. Yet the same eye that can do this can read a book at a distance of a few inches.

The remarkable thing about the eye is the retina, an enlargement and specialization of the optic nerve. This retina is composed of eleven layers, the tenth of which is "Jacob's Membrane" in which the rods and cones, peculiarly adapted to receive vibrations of light, give us the sense of color. Without these rods and cones . . . all the world would appear as a monotonous outline, for there is no color in the objects themselves.

Every object gives off a different vibration

of light, and when these vibrations reach the rods and cones, they stimulate the optic nerve, which carries the impression through half a dozen portals to the visual center in the back of the brain, and we see objects as blue, or red, or orange, and so on.

Especially when we consider the mosaic of the human retina with its elements regularly arranged, and set at distances of only one or two ten-thousandths of an inch apart, and think of these almost countless elements as destined to convey the impressions of the almost countless points which we can distinguish as separate in the field of view,—the impression of design seems inevitable.

Again, the eye has to be adapted to different degrees of light. This is done by the iris which is a kind of screen in the shape of a ring; this ring is capable of contracting or expanding so as to alter the size of the central hole or pupil, yet always retaining its circular form.

Moreover, it is somehow or other self-adjusting; for if the light is too strong the pupil at once contracts. It is useless to point out how useful such a contrivance would be in photography, and how much we should admire the skill of the inventor.

Once more, the eye can perceive objects in different directions; for it is so constructed that it can turn with the greatest rapidity right or left, up or down, without moving the head.

It is also provided in duplicate, the two eyes being so arranged that each can see separately. In case one is injured the other takes up the work entirely alone. Also, they work

> together in perfect harmony. . . . The whole process must have been designed.
>
> But the argument is far stronger than this. We remember that the eye was formed before birth. It was of no use when it was first made, but was intended for the future. This, when carefully considered, shows design more plainly than anything else.
>
> Moreover, an eye is found not in one man only, but in millions, each showing separately marks of design, and each requiring separately a Designer.
>
> Then, the human eye is only one example out of hundreds in the human body. . . . Finally human beings are but one kind of many thousands of organisms in nature, all bearing marks of design, and showing, in some cases, an even greater ingenuity than the human eye."

In "Natural Theology" Paley discusses the mechanism of the eye and shows its wonderful adaptation to its varied uses. There are certain fixed laws by which the transmission of light is regulated. For an organ to be able to see things both near and distant, there must be alteration in shape and adjustment of the eyeball. Rays from near objects must enter in a spreading or diverging manner; those from a distance must enter in practically parallel formation.

For close vision then, a rounder lens is required. As they meet, the light rays must fall accurately upon the retina, or vision will be con-

fused. Certain peculiar muscles were devised for this special purpose.

Three changes are produced:

1. The cornea is rendered more round and prominent.
2. The crystalline lens underneath is pushed forward.
3. The axis of vision, or the depth of the eye, is elongated.

Thus, the image falls on the retina at exactly the right place. The most mysterious laws governing optics must have been known to the Designer of this structure.

The lower animal creation have special life conditions and some peculiar changes were needed. Birds procure their food from points very near their beak. Their special equipment is interesting.

1. Either a bony or flexible rim or hoop is made to surround the broadest part of the eye, thus increasing the effect of the lateral pressure, and elongating the axis of the eyeball.

2. An additional muscle—the marsupim—is given to draw back the crystalline lens when distant objects are looked at.

Fish require that rays of light passing from the water into the eye, must be refracted by a

more convex surface. So, their crystalline lens is much more rounded in shape than that of terrestrial animals. In water, light is diminished and is never too strong. Accordingly, the pupil in fish does not contract.

The eel works its head through sand and gravel, and needs protection for the sensitive eyeball. To meet this need, it has a horny, convex case or covering, which does not obstruct light, but is sufficiently hard to defend the organ.

The whale spends much time hundreds of feet below the surface of the water where the pressure is enormous. So, this great mammal has a sclerotic coat for the eye, very thick and strong, and dense as leather, five times as thick behind as in front.

100 feet down, the pressure is 60 pounds to the square inch; at 4000 feet, 1830 pounds. But the whale can easily withstand this pressure and when attacked by its two natural enemies, the shark and the swordfish, although it has no real weapons, it carries them down to a depth which proves fatal to the attackers.

Chapter Twelve

YOUR BONES, MUSCLES, JOINTS

Your Skull

THE all-important brain with its delicate tissue must be well protected against the possibility of injury, and many devices have been adopted to insure safety under all normal and many abnormal conditions.

The skull is a mosaic of several bones beautifully joined and dovetailed into each other. At birth the union between the bones is loose so that immediate growth and enlargement is made possible. The new-born infant's brain is only one-fifth of its destined size, about ten ounces; it doubles in weight by the end of the second year and before twenty-five, has reached its maximum.

The adult brain is about one-thirty-fifth of the body weight; that of a gorilla, one hundred and twenty-fifth; while a humming-bird has a brain which weighs one-twelfth of its entire body.

The cranial box is a very strong affair. As previously noted, there are three tables or layers, the outer, the inner, with the mid-portion known as the diploe. The bone is thickest in front and behind and thinnest at the sides, the average being about one-fifth of an inch.

Several features contribute to its great strength, — its elasticity, composite formation, dome-shaped construction, and six remarkable buttresses at the junction of various bones. The tough nature of the scalp is also, indirectly, another source of strength, its protective value being distinctly higher than that of the soft parts covering bone in most other places.

The brain is covered with a set of membranes, three in number, the outer one, called the dura mater, being very tough and strong. This membranous bag has certain attachments passing out to the bones of the skull, which tend to sling or suspend it in its cavity, in a most ingenious manner.

The head must be able to change its position easily and quickly. Sometimes the need of the moment demands the ability to dodge dangerous missiles or make other necessary adjustments. It must be able to bend backward and forward as in nodding, stooping, and looking up and down.

It must be able to turn on itself,—about 120 degrees of a circle. These movements are made possible by the fact that the head rests on the upper portion of the spinal column and is united to the uppermost bone, the atlas, by a hinge joint

upon which the head plays freely back and forth, as far as the ligaments permit.

The rotary movement takes place between the atlas and the second vertebra, the axis, which has a tooth-like projection entering a socket in the superimposed atlas, thus forming a pivot or axle upon which the head and the attached first vertebra of the spine may turn freely in a circular direction. By these two devices, both kinds of movement are secured.

Your BACKBONE is a remarkable combination of strength and flexibility, admirably adapted to perform all its necessary functions. It has 24 sections, called vertebrae, 17 of which belong to the trunk. Each vertebra is a thick bony disc with outgrowths or processes, extending to the sides and rear, surrounding an open space, roughly circular.

The vertebral column has many functions. It furnishes a solid protection for the spinal cord, forms a central bony axis for the body, supports the skull, connects the lower extremities with the trunk, and forms a point of attachment for the ribs.

It must be firm in order to support the erect position of the body and the separate bones are so locked in and confined as to maintain their rel-

ative position nearly unaltered, thus preventing one vertebra from slipping out of line with the others.

The spine must also be flexible and this is obtained by the large number of bones, with the correspondingly large number of joints. This large degree of flexibility does not weaken the column because the breadth of the bony bases and the closeness of their junctions tend to preserve the firmness.

Flexibility is greatest where most needed—in the neck; least, in the back where firmness is more necessary; midway, in the loins where a moderate degree of motion must be provided.

The strain and pressure caused by bending is thrown almost entirely on the intervening cartilages. These are tough, resilient, yielding structures between each two bones, broader behind than in front, and their spongy, elastic nature prevents any interval from developing during changes of position.

The spine provides a unique canal for the safe conveyance of the spinal cord from the brain. The canal is formed by boring a hole in each vertebra in such a way that the opening in one falls into line with and corresponds to those above and below. This makes a close and uninterrupted

channel in which the delicate cord is strongly protected from shocks and injuries, to an even greater extent than is the case with the brain. The eighteen-inch-long spinal cord, extending down as far as the lower part of the first lumbar vertebra, is steadied throughout its course, by the anterior and posterior nerve roots on each side. These pass through notches or foramina made in the upper and lower edges of adjacent bones, in such a way that the nerves pass out in pairs, well sheltered from injury or pressure.

In order to provide for attachment of muscles and for support to the ends of the ribs, the back part of the bones comprising the spine projects out in a long process. This, of course, would not be possible in front because of the danger of injury to organs.

THE CHEST OR THORAX is a bony cage inclosing the organs of the upper half of the body. This cage is formed behind by the upper twelve of the seventeen vertebrae; on each side, by twelve ribs; and in front, by the breastbone or sternum. All the ribs are attached to the spine and the upper ten are joined also to the sternum, the lower two ribs loose at the front end, and so known as "floating." The spaces between all these bones are filled with muscles, lig-

aments, tendons, and membranes, forming an airtight cavity.

The chest is intimately concerned with the act of breathing, in which we behold another of those many wonderful mechanisms which abound in the body.

The ribs are joined to the backbone in an oblique manner. That is, in their natural position, they bend or slope downwards from their contact with the spinal column. Also, they are strongly curved.

Consequently, when they begin to move, whatever pulls them up, at the same time and necessarily, draws them outwards. This increases the lung capacity and draws in large supplies of air. If the ribs were connected with the vertebra at right angles, a change of position would not enlarge the capacity of the cage. By this peculiar construction, it makes a splendid bellows, superior to any similar contrivance, the product of a human artificer.

Your Muscles

of which there are about 300 on each side of the body, are made up of hundreds of thousands of small, individual muscle-cell engines. With each step more than one hundred million of these engines are at work.

Your motor mechanism weighs about eighty pounds—sixty of muscle and twenty of bone. We move because muscles have the power of contracting and relaxing, that is, of shortening and lengthening. The bones give support to the muscles which, in turn, move the bones as levers. At every step 300 muscles are cooperating.

They exist in opposing groups, one group counteracting the effect of the other. For instance, one group turns the head in one direction, another group brings it back again. Twenty muscles are needed to balance the head on the spine, and 144 to hold the spine erect at each step.

No adequate explanation has ever been offered to account for the mystery of a contracting and relaxing muscle.

Your Joints

are curiosities and wonders of mechanical art. There are two kinds, hinge, and ball and socket.

A hinge-joint has a strong, tough, parchment-like membrane projecting from the receiving bones and attached all around the ends of the received bones. This membrane encloses the joint on every side, holding together the ends of the bones in close application.

In order that there shall be no friction from

constant movement, the bones are covered at their ends with cartilage or gristle, and an oily fluid, synovial fluid, or "joint oil," is secreted by glands near the joint.

A ball and socket joint is what its name implies. The end of one bone is shaped like a ball, and is received into another which has a basin-shaped cavity to fit it. It is enclosed, like the hinge-joint, by a strong membrane, and, in addition, sometimes has a short powerful cord or ligament which fits into the rounded head of one bone and into the bottom of the cavity of the other. This makes for firmness and stability without any loss of flexibility.

Joints wear well, in fact, exercise seems to keep them in perfect condition, rather than wear them out. A joint kept at rest will lose much of its efficiency, the bone will become light and spongy, and the ligaments loose and relaxed.

Three reasons suggest themselves for the longevity of joint efficiency. First, the polished surface of the bone covered with cartilage which resists wear and friction. Second, the lubrication with the mucilaginous oil from glands close to the joint. Thirdly, the astonishing ability of all bony parts to repair and restore worn portions. A joint may swing on its hinge or play in its sock-

et hundreds of times an hour, for many years without any diminution of its action—no heating, no pain, no wear, no lessening of the ease of its operations.

The muscles and tendons around a joint are placed in exactly the right position to give the maximum amount of motion. Every joint can thus work to the limit of its ability. Muscles are always placed so as not to interfere with the action of each other. This arouses our admiration especially when we remember that hundreds of muscles lie very close together, some in layers over one another, some crossing and recrossing, some actually imbedded in the substance of or perforating another.

There are some very curious muscles. Some have slits to let others pass through them. They run in little grooves or canals sliding in and out with nice precision. In the fingers, the long tendon which bends the first joint, passes through the short tendon which bends the second joint. Muscles which connect legs to feet are bound down to the leg by a strap or ligament.

The muscle which pulls down the lower jaw is named the digastric muscle. It might be thought that if placed in the neck and attached to the chin, it would work satisfactorily. But, desir-

ing to preserve the shape, beauty, and symmetry of the neck, the Creator caused this muscle to originate rather high up on the side of the face. As it continues downward it changes into a round tendon.

It can readily be seen that, working directly in this relative position, it would pull the chin up instead of down. Accordingly, its action is changed. When the descending tendon reaches a certain point it is passed through a loop or pulley in the hyoid bone in the neck, and then made to ascend to the inner part of the chin where it is inserted. In this way, its contraction results in the pulling down of the lower jaw. Could evolution invent and construct such a plan?

All the movable parts of the bony skeleton are levers, the joints being fulcrums. Muscles attached to the bones near the joints raise or lower the levers.

The manner in which these levers are arranged enables you to scratch your back, play difficult music, perform on a trapeze, pick up pins, or twirl baseballs. You can push or pull, elbow your way through a crowd, punch noses, and perform tricks of sleight of hand.

In your hands are twenty-seven bones and many joints. Bulky muscles would mean clum-

sy fingers which could never play the piano, use pencil and pen, or perform any one of the thousands of actions needed. The device just referred to is adopted here and slender tendons, strong and graceful, replace the muscle. These pass from your forearm to various parts of wrist, thumb and fingers. The work is done in the forearm and the motions you see in the hands are similar to those of puppets—the strings have been pulled from a distance.

The human hand is one of the most marvelous of all of God's creations. It has strength, lightness and dexterity. No animal has a mechanism which equals it. No anthropoid has an opposable thumb, just a short stump incapable of the fine work of the human thumb.

From the first moment of waking until sleep comes at night, there is scarcely an activity in which the hands do not share. They seem to be indispensable.

Dr. Swartout writes interestingly on the mechanisms of the arms and hands. He points out many of the following facts.

The wrist has eight bones, arranged in two rows of four in each row. They are tightly bound together by ligaments, which however, permit a small amount of motion wherever one

bone touches another. This is necessary in order that the wrist may be flexible in all directions.

The forearm has two bones, the outer one called the radius, the inner one, the ulna. At the wrist, the radius makes a joint with three of the upper row of four wrist bones. This joint permits free bending forward and backward and also considerable motion from side to side.

The palm has five bones forming joints with the lower row of wrist bones. Here, only the thumb joint shows no motion. The joints between the bones of the palm and thumb, move freely backward and forward, and moderately from side to side.

Each of your fingers has three bones, but your thumb only two. All their joints are of the simple hinge type.

There are 20 small muscles in the hand, and their work is to separate the fingers, draw them together again, bend thumb and fingers, and bring your thumb into contact with any of the fingers.

The tiny muscles in the hand weigh only about one or two ounces. And yet the hand is capable of great feats of strength. Obviously, the little muscles must have help from some other source.

And that is what happens. Most of the power comes from the fleshy muscles in the forearm.

Hands not only do things, they express emotions. Language flows in a steady stream from the pen of a ready writer; an artist with swift sure strokes of his brush, transfers his dream to the canvas. A sculptor's hands and fingers, using mallet and chisel, carve out of solid rock figures which almost live. A great musician sweeps the keyboard of a piano or organ more swiftly than the eye can follow, never striking a wrong note, nor glancing at a single key. The fingers seem to have developed infallible eyes at their tips.

Father's hand on the young man's head imparts a paternal blessing; mother's loving fingers soothe the fevered brow of a sick child, and a mere hand-shake from a friend in time of need sends new strength coursing through your body. The fingertips of a blind person travelling over the raised letters of infinite smallness read with lightening speed. The eyes have transferred themselves to the fingers!

Is it any wonder that God uses the figure of arms and hands in giving to the children of men some of the most precious assurances they have ever known regarding His love and faithfulness?

"The eternal God is thy Refuge, and underneath are the everlasting arms. Behold I have graven thee on the palms of my hands."

Chapter Thirteen

GROWING OLD

AT birth, baby's cells are full of life and activity. 98% more growth may be expected if full development is achieved. Baby doubles weight in the first six months after which the rate of progress is more gradual. The last active period of growth is from the 14th to the 17th years, when 12% is added. This is the last big spurt. The 18th year sees a scant 4% increase and then the rate decreases until the 21st year when the body weight is complete.

Increase in length of body takes place likewise in spurts. The new-born baby is about 20 inches long; when able to walk, probably 34 inches. Thereafter, two or three inches yearly are added until puberty, at which time there is great activity in the growing cells. The most rapid year of growth in girls is the 13th, and for boys, the 16th. Between 14 and 16 a boy may add eight inches to his stature and you can almost see him springing up.

At the age of 18 a girl may have attained full development, but boys are not usually mature until about twenty-five, although both sexes may continue to grow for a few years longer.

The body has to make a constant struggle to maintain equilibrium. There must be steady production of heat and energy, repairs are always needed for failing organs, while there is ever present danger from attacks by virulent enemies of various kinds. We begin to die as soon as we are born.

As middle age is reached there are constant reminders that the sands are running out and the discovery is not pleasant. The skin loses some of its elasticity; wrinkles do not smooth out so easily, and there is a suggestion of bagginess in trunk and limbs.

Muscles, including those of the heart, shrink and grow flabby, as they become drier and stiffer. Fat partly wastes away and some of it is replaced by water. Ligaments in chest and abdomen lose their tone and begin to stretch, allowing the organs to sag. Bones dry out and become more brittle.

The curves of the backbone become more marked, and there is a thinning of the discs between the vertebrae. The walls of blood vessels harden and show a tendency to the deposition in them of lime and fat.

The activity of the vital organs generally shows a slowing down, and there is increasing

disability in handling loads which were easy in earlier years. Circulation becomes sluggish and it is more difficult to keep the hands and feet warm. The hot-water-bottle stage is reached. The pulse is slower, digestion weaker, and there is more tendency to faulty elimination. All the senses are less keen. The eye lenses begin to harden and glasses for reading become a necessity. The hair on the head has been thinning for some time in spite of the liberal use of many hair tonics.

The processes of repair are retarded, wounds and broken bones take longer to heal, and it requires more rest and sleep to recover from fatigue. In short, the body machine is wearing out, and the years will not be denied their toll.

Some fortunate people are born with a natural strength which does not show decline as early as others. Their probable life-span is increased, but the quality which brings this about is not understood. Many factors probably enter into the maintenance of youth, — activity of endocrine glands, the potency of their hormones, and some unknown gift of heredity. Longevity seems to run in families.

When a human reaches 100 years he becomes a curiosity and only rarely is this age exceeded. A tortoise will live to three hundred and fifty years

—but who would want to be a tortoise?

When signs accumulate to indicate that the old body will soon be discarded, one's thoughts inevitably turn to the new body which will presently be put on. How will this change be accomplished? What shall we be like?

Nothing is more certain than that another life succeeds this one, a life lived under vastly different conditions. There are many references to this life in the Word of God. For our present purpose it is enough to say that the new body will be a vast improvement over the one of flesh in which we now live.

The next great world event is the personal Return of Christ. This will bring an instantaneous change in the bodies of Christians living and dead.

> "Behold, I shew you a mystery; We shall not all sleep, but we shall all be changed, In a moment, in the twinkling of an eye, at the last trump: for the trumpet shall sound, and the dead shall be raised incorruptible, and we (the living ones) shall be changed. For this corruptible must put on incorruption, and this mortal must put on immortality" (I Cor. 15:51-53).
>
> "We know that, when he shall appear, we shall be like him; for we shall see him as he is" (I John 3:2).

There is no ambiguity here. We shall possess a

body exactly like the one Jesus had after His resurrection—the same one which He possesses now.

Before His crucifixion the body of our Lord was like ours. But, when He rose from the dead, what a difference! He could appear and disappear at will; He could enter a room without passing through open doors. He did not need food, but could take it, — even "broiled fish and honeycomb." His body had substance and could be seen and felt, but possessed supernatural powers. "We shall be **LIKE HIM.**"

"Like Him" — like God! Can this really be true? It must be. "O Lord my God, thou art very great; thou art clothed with honor and majesty. Who coverest thyself with light as with a garment." (Ps. 104:1-2.)

Light! Brilliant, blinding, majestic! The light of the sun pales into insignificance when compared to the effulgent glory which emanates from God, the Source of all light.

How powerful is sunlight? The deadliest weapon in the universe. Jeans tells us that this blazing mass of incandescent heat and light, God's central heating and lighting plant for the earth, 866,000 miles in diameter, with a mass more than a million times that of the earth, has

an internal temperature of at least 50,000,000 degrees Centigrade.

A pinhead heated to that point, would radiate energy at the rate of three quadrillion horsepower, would knock down fortresses by sheer pressure of radiation, and burn to a crisp any human within 1,000 miles. A pinhead!

The imagination reels and staggers when we attempt to form any conception of such wonders. Who can calculate even an infinitesimal fraction of the glory of God? And yet, that is to belong to us!

These eyes which now see a few shades of color will then behold countless thousands of unimagined hues. These ears which can detect but a few octaves of sound, will hear the magnificent symphonies of the skies. We shall know what music light makes as it travels from the distant stars; the song of angels will enchant and ravish our glorified senses. We shall know the music of rustling leaf and waving grass-blade. "We shall be like Him!"

"Ye are bought with a price: therefore glorify God with your body."

"Ye were not redeemed with corruptible things, as silver and gold . . but with the precious blood of Christ."

"God raised him up from the dead, and gave him glory."

"All flesh is as grass, and all the glory of man as the flower of grass. The grass withereth, and the flower thereof falleth away. But the word of the Lord endureth forever."

"I beseech you therefore, brethren, by the mercies of God, that ye present your bodies a living sacrifice, holy, acceptable unto God, your spiritual service."

THE END

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